

THE
ART of SHADOWS;
OR,

Universal Dialling;

WITH

TABLES exactly Calculated for the Lat.
of 51 deg. 30 min. viz. London.

Teaching any Person, tho' of an ordinary Capacity,
and unlearned in the Mathematics, to draw a true
SUN-DIAL, upon any given PLAN, however Situa-
ted, in respect of Declination and Reclination.

AND

A TABLE shewing the Distance of each Hour line
from the Meridian, upon all Horizontal-Dials.

LIKEWISE,

ARITHMETICAL,
SPOT, CONCAVE,
CONVEX,

}

{ INSTRUMENTS
{ REQUISITE

D I A L L

WITH

The manner of Ornamenting the
dialling with all Useful Furniture
five Regular Bodies, and two of
Rhombi, and the other of Thi

The Third Edition, with

By JOHN GOOD, Teacher

L O N D O N

Printed and Sold by RICHARD MOW
PAGE on Tower-hill, 1721.



THE PATENT OFFICE
OF THE UNITED STATES
IN RESPONSE TO A RESOLUTION
PASSED BY THE SENATE
ON THE 11TH DAY OF APRIL
1870
AND
A TABLE SHOWING THE
RESULTS OF THE
EXAMINATION OF
THE PATENT APPLICATIONS
FILED IN THE
PATENT OFFICE
DURING THE
MONTH OF
APRIL, 1870.



READER.



HIS Treatise of Dialling consisteth, as before, of Geometrical and Instrumental Dialling: And the Acceptance it hath found among the Ingenious, hath Encouraged me to add a Third Part, namely, an Arithmetical way by the Canons of Artificial Sines and Tangents: And there are in it, as before, the Tables of Hour-distances of all declining Dials, from one deg. of Declination to 60 deg. which I have Calculated myself, and I think they are very exactly done, so that you may depend upon them. The Instruments by which Dialling may be performed are many, but amongst them all I think I have made choice of the Best, namely, a Ruler, accommodated with Scales and Lines necessary for that Purpose.

The First Scale, is a Scale of Hours, each Hour divided as the bigness of the Scale will permit, being proper for all Dials that have no Declination, as the Horizontal, the Direct South and North, whether Upright or Reclining, except the Siles beight be less than 10 deg. When that happens, there are other Scales for that Purpose; and this Scale hath the Letters (Hours) at the beginning.

The Second Scale, is a Scale of 90 deg. answerable to the Scale of Hours, and may be divided as the length of the Scale will give leave: This Scale and the first, will together shew how many deg. and min. of the Equinoctial under, &c.

To the READER.

The Third Scale, is a Scale of Longitude, known by the Letters (Lat.) at the beginning.

The Fourth and Fifth Scales, are two Scales of Hours of a different length, either of them will serve to make East West, Equinoctial, and Equinoctial declining Dials.

Both these Scales together, serve to draw all such Dials, whose Style is but of small Elevation, and the Centre of the Dial is left out, and are known by the Letters (G. Pol.) and (L. Pol.) at the beginning.

It is proper to have two or three Lines of Chords, upon your Ruler, of several Raduses, and so have you a compleat Ruler.

And therefore if any Person be delighted with Recreation of this Nature, and hath not much Time to spend, they are here fitted with an Instrument which will dispatch presently and perform it exactly; they need not to fear to lose themselves in a Wilderness of Lines, nor out run the limits of the Plane, by infinite Excursion, (two inconveniencies which the common way of Geometrical Dialling is subject to,) they are here acquitted of both, having nothing to do but to draw the Dial itself, contracted within the Limits of the Plane. If any want Skill in the Mathematicks let them not deterre from this Subject, for there is little required of them. If some think the Canon more exact, so do I, but not so easy to be understood, nor so ready in use, nor so speedy in performance, nor truly so well fitting the Capacities of all Persons. I shall say nothing in Commendation of this Book, hoping it will speak for itself, I remain a Well wisher to the Mathematicks.

JOHN GOOD.

To the AUTHOR, on his Ingenious BOOK,
Intituled, The ART of SHADOWS; Or;
UNIVERSAL DIALLING.

I.
Does Time (*sub Deo*) *nolens volens* Rule
The Universe with uncontrolled Sway?
Do both Nature and Art, Wiseman and Fool,
His Law of Limit, all alike Obey?
Do all visible things on Time depend:
In Time Begin, Perfect, and make their End?

II.
Does every Orb of each denomination;
Whether the fixed Orbs or Wanderers,
Keep Time's unbroken Law of Limitation:
By *Minutes, Hours, Days, Weeks, Months, & Years*?
Does Time's Progress admit of no Cessation,
Till Eternity stop his Numeration?

III.
Is Time that's past beyond retivement lost,
Impossible to be restor'd again?
Does time that's present fly more swift than Post,
And ne'er one Moment, in one stay remain?
Can nothing stop Time's Feet, none hold his Wings,
Empires nor Emperors, Kingdoms nor their Kings?

IV.
Can neither Strength, Power, nor Policy?
Can neither Wisdom, Learning, Wit nor Art,
Riches, Grandeur, Honour, nor Majesty,
Stop Time's fleet Pace, or his Progress revert:
Nor Favour, nor Interest, nor Bribery
Stay Time's swift Passage to Eternity?

Does

V.

Does Time more swift than *Thought* or *Fancy* run;
Yet so, that he doth a fit Season lend
To ev'ry Purpose underneath the Sun

For to Begin, Perfect, and make its End?
Does Time rule all things, yet all things Obey
That will accept his Service, while they may?

VI.

If then, Time be the Best thing we Enjoy
Of all *Sub-lunar* Blessings we receive;
And greatest Wisdom be, Time well to Employ;
Which being lost, we never can retrieve:
Sure from these Premises, I may infer,
To watch Time's Passage, should be our chief care.

VII.

If so, then sure I may, (without denial)
Affirm that the most Useful Art, which by
The Art of *Shadows*, or a *True made Dial*,
From the Sun's bright Reflection, to each Eye,
Doth shew us how, (by easy Definition)
This swift Accomprant, sums up his Addition.

VIII.

Then sure above all, that e're writ the Art,
From Plainness, Fulness, Shortness, and Perfection,
GOOD doth this Universal Good impart,
To all Capacities, by his Direction:
For both by Instruments, and Calculation,
GOOD above all, makes good his Application.

WM. BRITTAIN, *Philomath.*

BOOKS PRINTED AND SOLD BY RICHARD
MOUNT and THOMAS PAGE; on
Tower-hill.

A TREATISE of *Trigonometry* Plane and Spherical, Theoretical and Practical, in which the several Cases of Plane and Spherical Triangles are solved Instrumentally and Arithmetically: And likewise, A Treatise of *Stereographic* and *Orthographic* Projection of the Sphere, in which the Principals and Theorems on which they depend are clearly demonstrated, and the Practice naturally deduced from those Demonstrations, Illustrated in the *Stereographic* Projection of the several Cases in Right and Oblique, Angled Spherical Triangles, so that the Requisites may be found without Calculation by Scale and Compass: By Samuel Heyns, Teacher of the *Mathematicks*.

Epitomy of Geometry, Being a Collection of the First, Third, Fifth and Sixth Books of *Euclid's* Elements, with their Application to several of the most useful Parts of the *Mathematicks*; Also *Euclid's* Second Book and Doctrine of Proportion Algebraically demonstrated; To which is subjoyn'd, a Treatise of measuring Superficies and Solids, Vulgarly, Geometrically and Practically; With the Customs used by Artificers in measuring their several Works; likewise Directions for measuring Board and Timber for making Vessels, of any Bigness; Taking the Plan of any Court, Yard, Garden, &c. Also the Cutting of the Five Regular Solids: By William Allingham, Teacher of the *Mathematicks*.

The History of *Fluxions*, Shewing in a compendious manner the first Rise of and various Improvement in that Incomparable Method. By the late Mr. *Joseph Raphson* A. M. and R. S. S. To which is added Letters between
Sir

BOOKS Printed and Sold, &c.

Sir Isaac Newton and Mr. Leibnitz relating to the first Inventor of Fluxions.

Geometry improv'd,

1. By a large and accurate Table of Segments of Circles, its Construction and various Uses of Solution of several difficult Problems, with Compendious Tables for finding a true proportional Part, and their Use in these or any other Tables exemplify'd in making our Logarithms or Natural Numbers from them to sixty Figures, there being a Table of them for all Primes to 1100 true to 61 Figures.

2. A Concise Treatise of Polyedra or solid Bodies of many Bases both the Regular and others; To which are added, Twelve new Ones with various Methods of forming them, and their exact Dimensions in Surdes or Species, and in Numbers Illustrated with Variety of Copper-plates by Abraham Sharp, Philomath.



The History of England, showing in a chronological and methodical manner the successive reigns of the several monarchs, from the first settlement of the Saxons to the death of King James the Second, by John Hume, Esq. To which is added a table of the reigns of the several monarchs.



INTRODUCTION;

Containing of

PROBLEMS and DEFINITIONS

Geometrical and Astronomical:

FOR THE

More easy apprehending, and ready Performing
of the several Matters and Things contain'd in
the following TREATISE.

PROP. I. FIG. I.

Upon any Point (as O) taken in the Right-Line
QR, to erect a Perpendicular OS.

1.  PEN your Compasses to any small
Distance; and setting one Foot in
the given Point O, with the other
Foot makes Marks on both the sides
of O, as at T and V.

2. Open the Compasses to any Distance, greater
than the former, and setting one Foot in T,
with the other describe the Arch *bb*: Also, with
the

the same Distance, set one Foot in V, and with the other describe the Arch gg, crossing the former Arch bb in the Point S.

3. Draw the Line OS, and it will be Perpendicular to the given Line QR.

PROB. II. FIG. II.

A Right-Line given, how to draw another Right-Line, which shall be Parallel thereto at any Distance required.

1. **L**ET the Line given be AB, unto which is required to draw another Right-Line CD, which shall be Parallel to the former Line AB, and at the Distance AC.

1. Open your Compasses to the Distance AC, then set one Foot in the Point A, with the other describe the Arch C; Again, place one Foot in B, and with the other describe the Arch D; then draw the Line CD so that it may only touch the two Arches C and D, so shall the Line CD so drawn, be Parallel to AB, and at the Distance required.

Astronomical Definitions.

THE Horizon is that part of the Heavens as a quick Eye can discern in an open Place; which divides the Heavens into two equal Parts. The middle Point of the Heavens which is over our Heads, is called the *Zenith*; and that under our Feet the *Nadir*.

2. The

2. The *Meridian* is a great Circle of the Heavens, passing through the Poles; the *Zenith* and *Nadir*, in which the Sun is at Noon, and at Twelve a Clock at Night.

3. The *Equinoctial* is a great Circle of the Heavens, dividing it into the Northern and Southern Hemispheres; and takes their Names from the two Poles, that being call'd the *Northern Hemisphere*, in which the *North-Pole* is seated; and that the *Southern* in which the *South-Pole* is seated. Unto this Circle when the Sun in his Annual Motion arriveth, (which is twice a Year) the Days and Nights are of an equal length through the whole World.

This Circle cutteth the *Axis* of the World at Right Angles, and is seated in the Heavens every ways 90 deg. distant from either of the Poles.

4. The two Topicks are *Smaller Circles* of the Heavens, described parallel to the *Equinoctial Circle*, and at 23 deg. 30 min. distance therefrom; that being the greatest *Declination* that the Sun hath from the *Equinoctial* towards either of the Poles. Of these Circles one is called the *Tropick of Cancer*, or Northern Tropick; the other the *Tropick of Capricorn*, or Southern Tropick. These two Circles are the Bounds or Limits of the Sun's Course, for between them he always moveth, never going more Northward or Southward, (that is, declines not nearer to any of the Poles) than 23 deg. 30 min. Wherefore, when the Sun in his Annual Motion, shall arrive to the *Tropick of Cancer*, which is about the 10th or 11th of June he maketh the longest Days to all inhabit the

Northern Hemisphere. And when he arriveth to the *Tropick of Capricorn*, which is about the 11th of *December*, he maketh the shortest *Days* to those that inhabit the Northern, and the longest to those of the Southern Hemisphere.

How to find a True Meridian-line; and the Azimuth of the Sun.

IT is very necessary to have a true *Meridian-line*, which may be obtained many ways, but the best I know for Practice is this;

Get a plain thick Board of a Foot Square, or more, then in the middle, or as near as may be, fasten a strong Iron Pin, about three Inches long, and make it so fast, that it will not shake or yield in the least: It matters not whether it be exactly Perpendicular, or not.

Set this Board Horizontally, with Earth or Sand upon the Ground; about Nine a Clock see where the Head of this Iron-pin (which must be sharp at top) giveth its Shadow upon the Board, mark that Place: Then take a wooden Ruler, sharp also at the end, and lay it so, upon the sharp end of the Iron-Pin, that the sharp end of the Ruler, may touch the Mark, then carrying it steady, describe a Circle.

Come again about Three a Clock in the Afternoon, and mark where the Shadow of the Top of the Iron-Pin is in that Circle again.

Draw a Line from those two Marks, which will be East and West, and the Perpendicular to that Line will be a true Meridian-Line. But

But because the Sun may be under a Cloud, when you come at three a Clock, you may make three or four more Circles, and use them as you used this.

When you have a true *Meridian-Line*, you will easily find the Sun's *Azimuth*, or Distance from the *South*; for hold but up a Plumb-line, and the Angle which the Shadow maketh with the *Meridian-Line* is the *Azimuth*; or you may lay the Edge of your *Quadrant* to the *Meridian-line*, and the Shadow of the Plumb-line passing through the Center, will give you the *Azimuth* in the Limb, and better than if you Calculated it by the Sun's *Altitude*.

How to make a Line of Chords to any Length or Radius.

First make a Right-line of any length as CBD, and upon the middle, by the first Problem, erect the Perpendicular AB.

Secondly, Open your Compasses to the Radius, or Length, that you would have your Line of Chords to be of, which suppose AB, and with that distance upon B, describe the Semicircle CAD.

Thirdly, Your Compasses being open to the same distance you describ'd the Semicircle, set one Foot in D, and make a mark in the Quadrant DA, as at R, then take with Compasses the distance on the Quadrant, from A to R, and set from R to S, so the Quadrant will be divided into 30, 60, 90,

B ;

deg.

deg. then divide DS, and SR, and RA, each into three Parts, which will be 10, 20, 30, 40, 50, 60, 70, 80 and 90.

Lastly, Set your Compasses in D, and open them to every one of the Nine Parts that the Quadrant is divided into by 10, 20, &c. and describe the prick'd Line as you see in the Figure.

Note: You may divide the Quadrant AD, if you will, into 90 equal Parts, if your Quadrant is large, and so transfer them from the Quadrant to the Line CBD, as you did by every ten Degrees.

PROB. III. FIG. III.

The Latitude of the Place, the Declination of the Sun, and the Altitude of the Sun being given, to find out the Azimuth, Geometrically.

	deg. min.	
The Latitude of the Place is	51 30	} North
The Declination of the Sun is	20 9	
The Altitude of the Sun is	18 2	

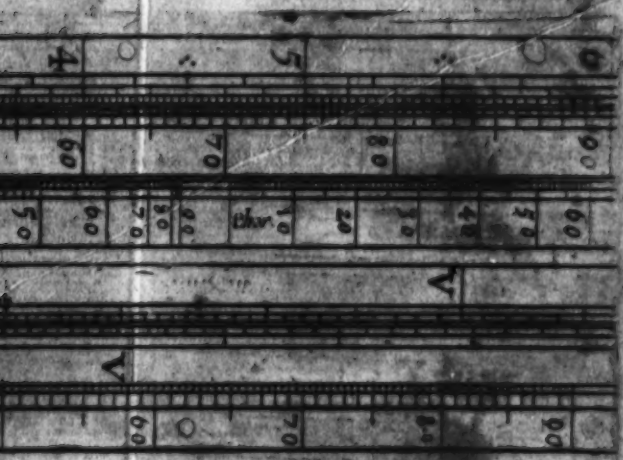
I. Upon the Center Q, describe the Semicircle HZO for half the Meridian, and upon Q, raise the Perpendicular QZ, for the Zenith.

II. Set 51 deg. 30 min. of your Line of Chords, which is the Latitude of London, from Z to E, and draw EQ from the Equinoctial.

III. Set 20 deg. 9 min. the Sun's Declination, from E towards Z, to the Point D, (being it is North) and draw the Line DT parallel to EQ, so is DBT the Parallel of the Sun's Declination.

IV. Set 18 deg. 2 min. the Sun's Altitude given, from

Hour	1	2	3	4
Inches	10	20	30	40
Lot	10	20	30	40
Pol.	I	II	III	IV
Pol.	I	II	III	IV
Chord	10	20	30	40



from O to L, and from H to M, and draw the Line ML, for the *Parallel of Altitude*.

V. Take your *Compasses*, half the length of the *Parallel of Altitude* SL, or SM; and with that Distance upon Q, describe the innermost Semicircle ACG.

VI. From the Point B, which is where the *Parallel of Declination*, and the *Parallel of Altitude* do intersect, erect the *Perpendicular* BC, till it touch the innermost Semicircle.

VII. Lay a *Ruler* from Q to C, and it will cut the outermost Circle in E; so HE measured upon a Line of Chords be 80 deg. the Sun's *Azimuth* from the North part of the *Meridian*.

VIII. EZ shall be 10 deg. the *Azimuth* from the East or West.

IX. Lastly, EQ shall be 100 deg. the *Azimuth* from the South part of the *Meridian*.

Note: And whereas throughout this *Book* there is continual mention made of *Degrees* and *Minutes*; know, that a Degree is the 360th part of any Circle, each of which Degrees is supposed to be divided into 60 Parts called Minutes, so that 45 Min. is three quarters of a Degree; 30 Min. half a Degree, and 15 Min. one quarter of a Degree, &c.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60

A Table of the Sun's Declination.

Day	January		Februa.		March		April		May		June	
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.
1	21	44	13	46	3	24	8	36	18	5	23	12
2	21	33	13	26	3	0	8	58	18	20	23	16
3	21	23	13	5	2	37	19	20	18	35	23	19
4	21	13	12	45	2	19	9	42	18	50	23	22
5	21	2	12	35	1	49	10	31	19	42	23	25
6	20	50	12	3	1	25	10	24	19	18	23	27
7	20	38	11	43	1	11	10	45	19	31	23	29
8	20	26	11	21	0	38	11	0	19	44	23	30
9	20	13	11	0	0	14	11	27	19	57	23	31
10	20	0	10	38	0	10	11	47	20	10	23	32
11	19	46	10	16	0	33	12	7	20	22	23	31
12	19	32	9	54	0	57	12	28	20	34	23	31
13	19	18	9	32	1	21	12	48	20	45	23	30
14	19	3	9	10	1	44	13	7	20	56	23	29
15	18	48	8	48	2	8	13	27	21	7	23	28
16	18	32	8	25	2	31	13	46	21	17	23	26
17	18	17	8	3	2	54	14	5	21	27	23	23
18	18	2	7	40	3	18	14	24	21	37	23	20
19	17	45	7	17	3	41	14	42	21	46	23	17
20	17	28	6	54	4	5	15	1	21	55	23	14
21	17	11	6	31	4	28	15	19	22	4	23	10
22	16	54	6	8	4	51	15	37	22	12	23	6
23	16	36	5	45	5	14	15	54	22	20	23	1
24	16	18	5	21	5	37	16	12	22	27	23	55
25	16	0	4	58	6	0	16	29	22	34	23	50
26	15	42	4	34	6	22	16	46	22	41	23	44
27	15	23	4	11	6	45	17	2	22	47	23	37
28	15	4	3	47	7	7	17	18	22	53	23	31
29	14	45	3	39	7	30	17	34	22	59	23	23
30	14	26			7	52	17	50	23	3	23	16
31	14	6			8	14		23	8			

A Table of the Sun's Declination.

Day	July		August		Septem.		October		Novem.		Decem.	
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.
1	23	8	15	12	4	24	7	15	27	40	28	9
2	22	0	14	55	4	2	7	38	17	56	23	42
3	21	5	14	36	3	38	8	0	18	12	23	17
4	21	42	14	17	3	15	8	22	18	28	23	20
5	21	32	13	58	2	32	8	45	18	43	33	23
6	21	22	13	39	2	29	9	7	18	58	23	26
7	21	12	13	20	2	3	9	29	19	13	23	28
8	21	2	13	1	1	42	9	51	19	27	23	30
9	20	51	12	41	1	19	10	13	19	41	23	31
10	20	40	12	21	0	55	10	33	19	55	23	31
11	20	28	12	1	0	32	10	56	20	8	23	31
12	20	16	11	41	0	8	11	48	20	21	23	31
13	20	4	11	21	0	16	11	39	20	34	23	29
14	19	51	11	0	0	39	11	0	10	46	23	17
15	19	38	10	39	1	3	12	21	00	58	23	25
16	19	25	10	18	1	26	12	41	21	9	23	22
17	19	12	9	57	1	50	13	28	1	20	23	19
18	18	58	9	36	2	13	13	22	21	31	23	16
19	18	43	9	15	2	37	13	42	21	41	23	12
20	18	23	8	53	3	0	14	2	21	50	23	7
21	18	14	8	31	3	25	14	21	22	0	23	2
22	17	59	8	9	3	47	14	43	22	9	23	0
23	17	44	7	47	4	10	15	0	22	13	22	57
24	17	28	7	25	4	33	15	19	22	47	22	51
25	17	12	7	3	4	57	15	37	22	31	22	44
26	16	56	6	41	5	20	15	55	22	40	22	27
27	16	39	6	18	5	46	16	1	22	46	22	30
28	16	22	5	56	6	6	16	3	22	52	22	22
29	16	6	5	33	6	29	16	49	22	58	22	15
30	15	48	5	10	6	52	17	6	23	4	22	9
31	15	30	4	47		17	18		23	22	22	50

The End of the Introduction.



How to find the Situation of any Plane, from the South or North, towards either East or West; commonly called the Declination of a Plane.

THE Declination of a Plane, is an Arch of the Horizon comprehended between the Pole of the Plane, and the Meridian of the Place. Or it is the distance of the Plane itself, from the prime Vertical Circle, or Azimuth, of East and West.

To find out the Declination of any Plane, there are required two Observations to be made by the Sun at the same instant of time. The first of the Sun's Horizontal distance from the Pole of the Plane, and secondly, of the Altitude of the Sun.

First. To find the Sun's Horizontal Distance from the Pole of the Plane. Apply one edge of a Quadrant, to the Horizontal-Line of your Plane, so that the other may be Perpendicular to it, and the Limb of the Quadrant must be towards the Sun; and hold the whole Quadrant Horizontal as near as you can conjecture. Then holding up a Thread and Plummer, at full Liberty, so that the Shadow of the Thread, may pass both thro' the Center and Limb of the Quadrant, observe then the Degrees cut by the Shadow of the Thread, and number them from that side of the Quadrant that standeth square or Perpendicular to the

the Plane: For those Degrees are the *Horizontal Distance* required.

Secondly, This *Horizontal Distance* and the *Sun's Altitude* being observed at the same time (as near as may be) will help you to the *Planes Declination* in this manner.

When you make your *Observation* of the *Sun's Horizontal Distance*, mark whether the *Shadow* of the *Thread*, fall between the *South*, and that side of the *Quadrant*, which is *Perpendicular* to the *Plane*.

I. If the *Shadow* fall between them, the *Azimuth* and *Distance* added together, do make the *Declination* of the *Plane*, and in this Case the *Declination* is upon the same *Coast* whereon the *Sun's Azimuth* is.

II. If the *Shadow* fall not between them, subtract the lesser of them from the greater, and the remainder shall be the *Plane's Declination*; and if the *Azimuth* be the greater of the two, the *Plane* Declines to the same *Coast* whereon the *Sun* is, but if the *Distance* be the greater, then the *Plane* Declines to the contrary *Coast*.

And here Note, That the *Declination* thus found is always accounted from the *South*, and that all *Declinations* are counted from either *South* or *North*, towards either *East* or *West*, and must never exceed 90 Degrees.

I. If therefore the degrees of *Declination* do exceed 90, you must take the residue of that Number to 180, and that shall be the *Plane's Declination* from the *North*.

II. If

II. If the Degrees of Declination exceed 180 deg. then the excess above 180 deg. gives the *Plane's Declination* from the North towards the *Coast*, which is contrary to the *Coast* whereon the *Sun* is.

But seeing the Declination is the Angle contained between the Perpendicular from the *Wall* and the *Meridian*, it may be the best to wait in fair Weather, till you find the *Sun* in the *Meridian*; and then the Angle upon the Limb of the *Quadrant*, will itself be the Declination.

Description of DIALLING.



DIALLING is an Art teaching how to Measure the time of the Day, by the shade of the *Sun*; and originally is a *Mathematical Science*, attained by the Philosophical contemplation of the motion of the *Sun*, the motion of the *Shadow*, the Constitution of the *Sphere*, the Situation of *Places*, and the consideration of *Lines*. The motion of the *Sun* is regular, in moving equal Space in equal Time; but the motion of the *Shadow* irregular in all parts of the Earth, unless under the two Poles, and that more or less according to the Constitution of the *Sphere*, and the Situation of the *Place*.

And

And therefore by Art there is found out Rules to mark out the irregular Motion of the *Shadow* in all *Latitudes*, and on all *Planes*, to comply with the regular Motion of the *Sun*. And these Rules of adjusting the Motion of the *Shadow* to the motion of the *Sun*, may be called the Art of *Shadows*.

Of the several Sorts of *Planes* upon which
DIALS are usually made.

Definitions.

A *Dial Plane* is that Flat whereon a *Dial* is intended to be made.

Of *Dial-Planes* some be *Direct*, others *Decliners*, and others *Oblique*.

Of *Direct Planes* there are five sorts.

1. The *Horizontal*, whose Plane lies flat, and is parallel to the *Horizon*, beholding the *Zenith*.

2. The *South Erect*, whose Plane stands upright, and directly beholds the *South*.

3. The *North Erect*, whose Plane stands upright, and directly beholds the *North*.

4. The *East Erect*, whose Plane stands upright, and directly beholds the *East*.

5. The *West Erect*, whose Plane stands upright, and directly beholds the *West*.

Of *Decliners* there are infinite; and yet may be reduced into these two *Kinds*.

1. The *South Erect Plane*, declining more or less towards the *East* or *West*.

2. The

2. The *North Erect Plane*, declining more or less towards the *East* or *West*.

Of *Oblique Planes* some are *Direct*, others *Declining*. Now an *Oblique Plane* is (as to explain it to a mean Capacity) a Plain, or Dial which falls or leaneth from you like the Roof of an House, and are of these Kinds:

1. The *Direct South-Dial* Reclining.
2. The *Direct North-Dial* Reclining.
3. The *Direct East or West* Reclining.
4. The *North and South Declining* Reclining Dials.

Note 1. That all Angles are usually measured by a Line of Chords, whose *Radius* or *Semi-diameter* is equal to the Chord of 60 deg. and do contain 90 deg. which is a Quadrant; sometime by a Tangent-line.

2. If the Hours of a Dial be never so truly drawn, if the *Stile* be not well plac'd, it will not go exact; therefore observe these three Rules in setting your *Stile*.

1. That it has the same Center (if there be any) with the *Substile* and Hours.

2. Its due Angle.

3. That it stands perpendicular to the *Substile*.

4. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

5. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

6. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

7. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

8. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

9. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

10. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

11. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

12. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

13. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

14. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

15. The *Stile* must be drawn so that it may be perpendicular to the *Substile*.

Multum

THE Art of SHADOWS

TABLES, &c.



CHAP. I. FIG. IV.

How to draw an Horizontal Dial.

1. DRAW the Line AB, for 6 and 6 Morning and Evening.

2. Draw NS, perpendicular to AB; this shall be the 12 o'Clock Hour-line.

3. Let C, the Intersection of the foresaid Lines be the Center of the Dial, then take in your Compasses 60 deg. of a Line of Chords, and with that Distance upon the Center C draw an obscure Segment of a Circle, as Amb.

4. Turn to your Table of Horizontal Spaces, and see what Degrees and Minutes answer to 11 and 12 o'Clock; you find they are 11 deg. 51 min. take therefore 11 deg. 51 min. out of your Line of Chords, and set it from m to bk, on both sides the 12 o'Clock Line.

Likewise take 24 Deg. 20 Min. for 10 and 2 o'Clock, and set it from m to bk. Take 38 deg. 4 min. and set it from m to ec; work after the same manner for the remaining Hours.

5. From

5. From the Center *C*, thro' each of these Points *a*, *b*, *c*, *d*, *e*, draw Lines, which shall be the Hours required. The intermedial Spaces, viz. Quarters, Half and three Quarters of an Hour, are drawn after the same Method.

Lastly, The *Stile* of your Dial must always make an Angle equal to the *Latitude* of the Place. Take therefore 54 deg. 30 min. out of your Line of Chords and set it from *m* to *n*, thro' *C* and *n* draw the Line *Cn*.

Note 1. That the *Stile* must stand at Right Angles with the *Plane* upon the 12 a Clock-Line.

2. That the 12 a Clock-Line must be set exactly North and South.

3. That the whole *Plane* must be laid parallel to the *Horizon*.

4. That the 2 Hours above the Line of 6, are drawn by extending the two opposite *Hour-lines* thro' the *Center*; as in the Morning is drawn by extending in the Afternoon;

CHAP. II. FIG. V.

How to draw the Hour-lines upon a Direct South-Dial.

THERE is little Difference between describing a South-Dial and an Horizontal-Dial; only Observe,

1. That the Angle which every Hour-line makes with the *Meridian* must be taken from the Table of South-Dial Spaces, and prick'd down on the

the Segment of the Circle A, B, $\bar{m}$, as before directed in the *Horizontal Dial*.

11. 2. That the Angle which the Stile makes with the *Meridian* must be 38 deg. 30 min. always the Complement of your *Latitude*.

Note; That the Stile must stand at Right Angles with the Plane.

2. That the Face of the Dial must look exactly South, and be placed perpendicular to the *Horizon*.

C H A P. III.

Fig. 6.

How to draw the Hour-lines upon a Direct North Dial.

A *Direct North Dial*, is the same with a *Direct South Dial*; for, if you take a *South-Dial* and turn it upside down, causing the Stile to point upwards, as the Stile of the *South* doth downwards, and leaving out the Hours near the *Meridian*, in these *Northern Latitudes*: as the Hours of 9, 10, 11, and 12 at Night, and 1, 2, and 3 in the Morning, all which time the Sun is under the *Horizon*. I say a *South-Dial* so inverted, and fixed against a *direct North Wall*, shall give the true Hour of the Day.

C H A P. IV.

Fig. 7.

How to draw the Hour-lines upon a Direct, East or West Dial.

1. UPON the point C, if it be an *East-Dial*, or upon the point D, if a *West*, with 60 deg. of your line of Chords draw an obscure Segment of

C

of

of a Circle EF; then take 38 deg. 30. min. the Complement of your Latitude, and set it from E to F, and draw CF thro' the Plane. Call this Line the Equinoctial.

2. Assume any two points in this Equinoctial at a convenient distance for the Hour-lines of 11 and 6; and thro' these points GH, draw Perpendiculars to the Equinoctial.

3. On G with 60 deg. of your Line of Chords, describe an obscure Arch of a Circle IK, and set thereon 14 deg. from I to K, and draw the Line GK, to cut the Hour-line of 6 in the Point L, so that LH be the Height of the perpendicular Stile porportioned to this Plane.

4. Upon L with 60 deg. of Chords, describe an Arch of a Circle M, N: between the Hour-line 6 and G L. Divide the Arch MN, into five equal parts with 11 deg. of Chords. Then turn to your Table for East and West Dials, and see what number stands against each hour, (and the Intermediate Spaces, if you please to put them in) take the said numbers out of your Line of Chords; and put them upon the Arch MN, from M to N.

5. Lay a Rule from L to each of the Divisions , &c, and where the Rule intersects the Equinoctial-line, make marks ***, &c. Lines drawn thro' these points ***, &c. Parallel to the Hour-line of 6, shall be the true Hour-lines for an East Dial from 6 to 11; but if you transfer the same distances on the Equinoctial before 6, as there is after 6, and thro' these distances draw lines parallel to 6; you have also the hours before 6, as 5, 4, &c.

Note; 1. That the Stile may be a plate of Brass

or

or Iron of the same breadth as is the distance between 6 and 9 on the *Equino-Dial*, and fixed upon the line of 6, perpendicular to the Plane.

2. That an *East* and *West Dial* is the same in all Respects, save that the hour-lines of 4, 5, 6, 7, 8, in the Morning in the *East Dial*, must be 7, 6, 5, 4, in the Evening on the *West Dial*.

CH A P. V. *Fig. 8.*

How to draw the Hour-lines upon South or North Planes, Declining either East or West, 30 deg.

1. **D**R A W the Line NS for 12 a Clock Hour-line.

2. In this Line choose a Center as C, upon which with 60 degrees of Chords, describe an obscure Circle.

3. Turn to your Table of *Requisites*, and see what is the Substile distance for 30 Degrees of Declination; 'Tis 21 deg. 40 min. take the said distance out of your Line of Chords, and set it from M to S: thro' C and S draw an obscure Line for the Substile.

4. Now turn to your *Declination* in the Tables of *Hour distances* for the Substile, and see what numbers stands against each Hour (and $\frac{1}{2}$ part if you would insert them in your Dial) transfer these numbers by help of your Line of Chords into the Circle from S, towards AB; and thro' the Points draw Lines from C, the Center of your Dial; these are the Hours required.

5. And lastly, In your Table of *Requisites*, under the Stiles height, and opposite to 30 deg. of Declination, you'll find 72 deg. 37 min. Set

this distance from S to T, then draw CT, and you have the height of the Stile or Gnomon.

Note 1. That the larger the Radius of your Line of Chords is, the better you may insert the Hour-lines.

2. If the Declination be *East*, the Substile must be placed on the left side of the *Meridian*; and those hours that are next to the numbers in your Table must be used: But the contrary, if the Declination be *West*.

3. If the Face of your Dial be towards the *North*, you must turn the Dial the Bottom upwards; and reckon the Hours the contrary way; So a *South East Decliner* will be a *North East Decliner*, and a *South West Decliner*, will be a *North West Decliner* leaving out the Hour-lines, (which will be needless) before Sun-setting, and after Sun-rising.

4. That the Stile must be fix'd upon the Substile, and stand at Right Angles with the Plane.

C H A P. VI. Fig. 9.

How to draw the Hour-lines upon an Equinoctial Plane.

1. **D**R A W the Right Line AB, for the Horizontal Line of the Plane, and cross it about the middle thereof at Right Angles, with a Line 12 Q 12, for the Meridian and Hour-line of 12.

1. Upon the Line 12 Q 12, either above or below Q, assume any Point at S, and setting one foot of your Compasses therein, (it being opened

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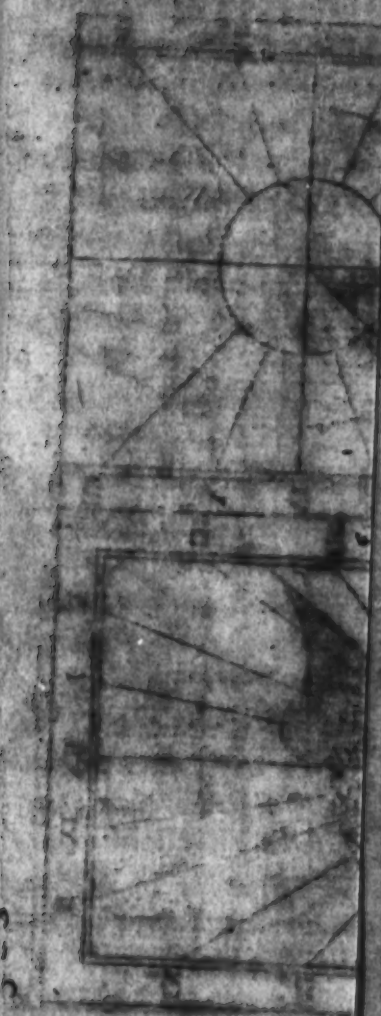




Fig 2.

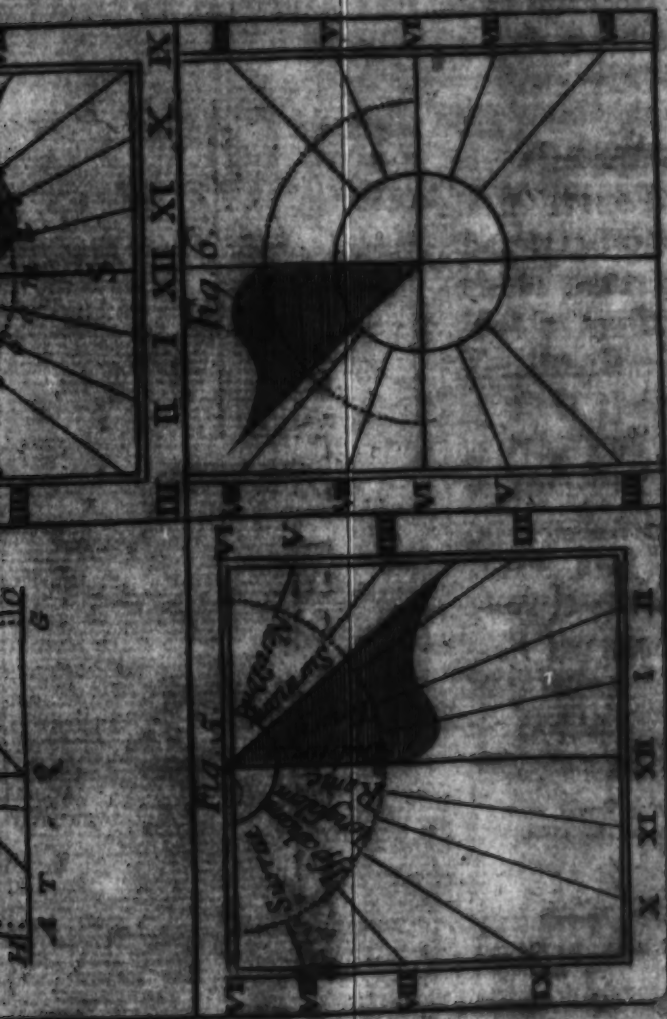


Fig 1.



Fig 3.





to the Radius of your Line of Chords) describe the Circle CDE, which divide into 12 equal parts, beginning at D. Lay a Rule to S, and the several Points $\odot \odot \odot$, &c. and it will cut the Line AB, in the Points $\ast \ast \ast$, &c.

Lastly, Through these Points $\ast \ast \ast$, &c. draw Right Lines all parallel to the Line $12 Q 12$, and so your Dial is finished.

The Scale may be either a straight Pin, of the length of the Line QS, and set perpendicular to the Plane, upon the point Q; the shadow of the Top thereof only giving the Hour.

Or it may be a plate of Brass or Iron, of the breadth of the distance that is between the Hour-line of 12 and 3, or 12 and 9. And then will the shadow of the upper edge thereof give the true Hour of the Day.

C H A P. VII.

Fig. 10.

How to draw the Hour-lines upon a Direct Polar Plane.

1. **D**escribe the Circle ABDE, with 60 deg. of your Line of Chords.
2. Draw the Diameters AC and AD at Right Angles, in the Center O. AC shall be the hour of 12, and BD the hour of 6.
3. Turn to your Table of *Polar Dial*, and see what numbers answer to every hour, take the said Numbers from your Line of Chords, and prick them down in the Circle ABCD, on both sides the 12 a Clock-line: Draw lines from these Points thro' the Center O, and your work is done.

C 3

Note 1.

Note 1. That this *Plane*, by reason of its *North Declination*, is in *Summer*, capable of receiving all the *Hours* from *Sun-rising* to *Sun-setting*, and therefore the *Hour-lines* of 4 and 5 in the *Morning*, and of 7 and 8 at *Night*, must be drawn through the *Center*, as you did in the *Horizontal Dial*.

Note 2. That the *Hour-line* of 12 must stand exactly *North* and *South*.

Note 3. That the *Plane* must be elevated the same number of *Degrees* towards the *South*, as the *Equator* is in your *Latitude*.

Note 4. The *Stile* must be a straight *Pin* or *Wire*, (set perpendicular to the *Plane*, from the *Center O*) of any length.

Note 5. The *South inclining Plane* opposite to this, is directly the same, only the *Forenoon* hours in this must be the *Afternoon* in that, and the hours of 4 and 5 in the *Morning*, and of 7 and 8 in the *Evening*, must be omitted.

C H A P. VIII.

Fig. 11.

How to draw the Hour-lines upon Far-Declining Dials.

BECAUSE the *Tables* extend no farther than 60 deg. of *Declination*, (and if they had been *Calculated* to 90 deg. they would have been of little use, because the *Stile's* height being so small, the *Hour-lines* would have been of no *Competent Distance*) and because many times there may be *Occasion* to make a *Dial* for a greater *Declination*, I will shew a *Geometrical* way to draw

draw such, by the help of a Line of Chords only.

Let the Declination given be 80 deg. Eastward.

1. Draw a Line BC, perpendicular to the Horizon of the Plane.

2. Upon C, with a Chord of 60 deg. describe the Arch QS, then out of the Table of Regulares take the Substile's distance, and let it from Q to N; take also the Stile's height, and let it from N to E.

3. Draw CD for the Substile, and CE for the Stile: Then at any convenient distance draw KL parallel to CE the Stile. Also assume any two points in the Substile, and thro' them draw the Perpendiculars FG, and HI.

4. Take the nearest distance from T to KL, and from Y to KL, and let it from T to R, and from Y to D.

5. Upon D and R, with 60 deg. of Chords, describe two Arches of a Circle, and let off the Inclination of the Meridian from T to P, and from V to O. With 75 deg. of Chords divide the Segments into equal parts, beginning at O and P.

6. Lay a Rule on D, and on each division in the Arch VO, and mark the Intersection of the Rule with the Line FG. Then lay the Rule to R, and work after the same manner in other Arch, and HI.

7. Thro' the marks made in HI, and GF, draw the Hour-lines.

Note 1. When the Plane declines Westward, the perpendicular CB must be put on the Right-hand.

2. That the Inclination of the Meridian must be set on the same side of the Substile with the Perpendicular.

Thus have you finished your Dial, and in the making of this, you have made a *South* declining *West* 80 deg. also; for if you turn the paper, and look through it, it will on the back-side be a *South* declining *West* 80 deg. only the Forenoon hours in this, must be Afternoon in that: Nay, of right you have made in this one Dial Four, viz. a *North*, declining either *East* or *West*, if you well observe what was said of the Dial declining 30 deg.

COH. A. P. LX.
How to place an Upright Dial truly.

ALL Upright Dials, in what Latitude soever, have the *Meridian* perpendicular to the *Horizon*, Therefore set your Dial exact, hang a Line with a Plummert at the end thereof, upon a Nail fixt in the Line of 12 toward the top; then apply your Dial to the Place where it is to be fixt, so that the Line and Plummert may hang just down upon the Line of 12: The Dial thus fixt (if the Declination be truly taken, and the Dial made by the former directions) will at all times (if the Sun's on it) give the true Hour of the Day.

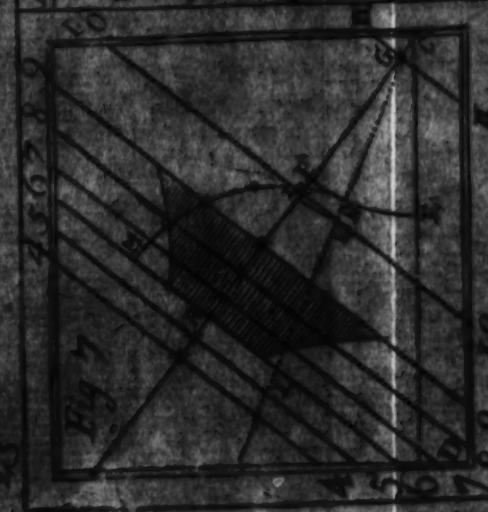
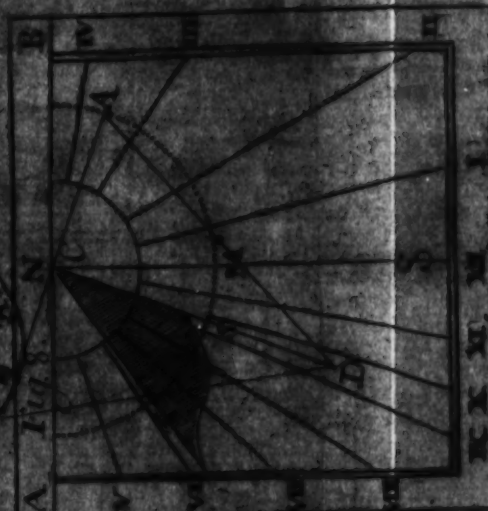
Note. In every Dial truly placed, if you stand on the South-side of the Plane looking Northward, the Hours on your Left-hand of the *Meridian*, are the Morning-Hours, on your Right-hand are the Evening-Hours; but if you stand on the North-side of the Plane, your Face being Southward, then the Forenoon-Hours are on your Right-hand, and the Afternoon-hours on your Left-hand; because your Right-hand, in relation to the Plane, is where your Left-hand was.

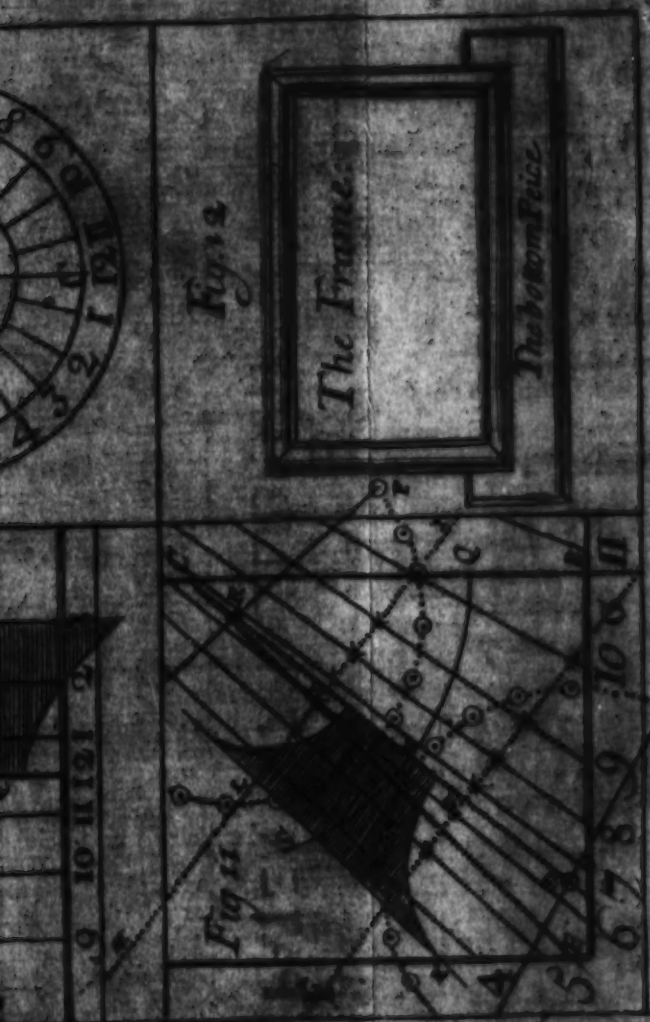
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The Three Requisites in Dialling, Calculated to every Degree of Declination, in the Latitude 51 deg. 30 min.

Declination.	Sub- stile's		Stile's height.	Incl- ination of Me- ridian.		Declination.	Sub- stile's		Stile's height.	Incl- ination of Me- ridian.			
	Di- stance Meri- dian.			Di- stance Meri- dian.			Di- stance Meri- dian.						
	d.	m.		d.	m.		d.	m.		d.	m.		
1	00	48	38	29	1	17	22	16	36	35	16	25	18
2	1	36	38	28	1	33	23	17	16	34	57	28	39
3	2	23	38	26	3	49	24	17	56	34	39	29	38
4	3	11	38	23	5	07	25	18	37	34	21	30	47
5	3	58	38	20	6	23	26	19	13	34	03	30	56
6	4	45	38	15	7	39	27	19	50	33	42	33	04
7	5	32	38	10	8	55	28	20	29	34	20	34	12
8	6	19	38	04	10	11	29	21	05	32	59	35	19
9	7	05	37	57	11	27	30	21	40	32	37	36	25
10	7	52	37	49	12	42	31	22	15	32	15	37	31
11	8	38	37	40	13	57	32	23	50	31	52	38	36
12	9	23	37	30	15	10	33	13	25	31	27	39	41
13	10	08	37	21	16	26	34	23	59	31	04	40	46
14	10	54	37	10	17	40	35	24	31	30	40	41	49
15	11	38	36	58	18	54	36	25	04	30	14	42	52
16	12	22	36	43	20	07	37	25	35	29	48	43	55
17	13	05	36	32	21	20	38	26	04	29	22	44	58
18	13	49	36	18	22	33	39	26	33	28	56	45	59
19	14	31	36	03	23	45	40	27	03	28	29	47	00
20	15	13	35	48	24	57	41	27	33	28	01	48	00
21	15	54	35	31	26	08	42	28	01	27	33	49	00

The Three Requisites in Dialling, Calculated to every Degree of Declination, in the Latitude 51 deg. 30 min.

Declination.	Sub- stile's Di- stance Meridi- an.		Stile's height.		Incli- nation of Me- ridian.		Declination.	Sub- stile's Di- stance Meridi- an.		Stile's height.		Incli- nation of Me- ridian.	
	d.	m.	d.	m.	d.	m.		d.	m.	d.	m.	d.	m.
43	28	29	27	03	50	00	67	36	13	14	05	71	38
44	28	55	26	36	50	59	68	16	25	13	29	72	27
45	29	21	26	07	51	57	69	35	36	12	53	73	16
46	29	46	25	37	52	55	70	36	46	12	18	74	06
47	30	11	25	07	53	55	71	36	55	11	41	74	55
48	30	35	24	38	54	50	72	39	06	11	06	75	44
49	30	38	24	06	55	46	73	37	15	10	29	76	33
50	31	21	23	35	56	42	74	39	24	09	53	77	21
51	31	45	23	04	57	38	75	37	32	09	16	78	09
52	32	05	22	32	58	33	76	39	40	08	40	78	57
53	32	26	22	00	59	28	77	39	47	08	03	79	46
54	32	46	21	28	60	23	78	38	57	07	27	80	33
55	33	06	20	55	61	17	79	37	59	06	49	81	21
56	33	24	20	02	62	10	80	38	04	06	12	82	09
57	33	42	19	49	63	04	81	38	09	05	35	82	56
58	34	00	19	16	63	57	82	38	14	04	58	83	43
59	34	15	18	42	64	49	83	38	17	04	20	84	31
60	34	33	18	06	65	41	84	38	21	03	44	85	18
61	34	47	17	34	66	33	85	38	23	03	06	86	05
62	35	05	17	00	67	24	86	38	26	02	28	86	52
63	35	18	16	25	68	16	87	38	28	01	52	87	39
64	35	34	15	50	69	07	88	38	29	01	15	88	26
65	35	43	15	15	69	57	89	38	29	00	37	89	31
66	36	00	14	40	70	47	90	38	30	00	00	90	00

A Table of Horizontal Spaces, shewing the Distance of each HOUR-LINE from the MERIDIAN upon DIRECT NORTH or SOUTH Planes, whether Erect, Reclining or Inclining: Calculated to every Degree of LATITUDE.

Direct North Latitudes	xi.		i. x.		ii. ix.		iii. viii.		iv. vii.		v.		vi.		Direct South Latitudes
	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	d.	m.	
0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
1	00	16	00	34	01	01	44	3	44	30	00	00	00	00	00
2	00	32	01	02	03	03	27	7	25	30	00	00	00	00	00
3	00	48	01	44	05	05	11	11	3	30	00	00	00	00	00
4	01	52	01	44	06	06	54	14	36	30	00	00	00	00	00
5	01	20	02	52	08	08	35	18	1	30	00	00	00	00	00
6	01	36	03	27	09	09	10	21	19	30	00	00	00	00	00
7	01	52	04	36	11	11	55	24	27	30	00	00	00	00	00
8	02	8	04	37	13	13	33	27	23	30	00	00	00	00	00
9	02	23	05	08	14	14	54	15	10	30	00	00	00	00	00
10	02	40	05	43	16	16	44	32	37	30	00	00	00	00	00
11	02	55	06	17	18	18	17	35	27	30	00	00	00	00	00
12	03	11	06	51	19	19	48	37	49	30	00	00	00	00	00
13	03	27	07	24	21	21	17	40	1	30	00	00	00	00	00
14	03	43	07	57	23	23	44	42	4	30	00	00	00	00	00
15	03	58	08	30	24	24	9	44	0	30	00	00	00	00	00
16	04	13	09	2	25	25	30	45	49	30	00	00	00	00	00
17	04	29	09	35	26	26	52	47	26	30	00	00	00	00	00
18	04	44	10	8	27	27	10	28	9	30	00	00	00	00	00
19	04	59	10	39	28	28	22	29	25	30	00	00	00	00	00
20	05	14	11	10	28	28	33	30	39	51	55	30	00	00	00
21	05	29	11	41	29	29	44	31	10	53	9	30	00	00	00
22	05	44	12	13	20	32	32	38	54	21	30	00	00	00	00
23	05	59	12	43	21	20	34	55	55	30	30	00	00	00	00
24	06	13	13	13	22	8	35	10	56	37	30	00	00	00	00
25	06	28	13	43	22	55	36	12	57	34	30	00	00	00	00
26	06	42	14	12	23	40	37	13	58	34	30	00	00	00	00

A TABLE of Horizontal Spaces, &c.

Dial, Latitude.	xi. i.		x. ii.		ix. iii.		viii. iv.		vii. v.		vi.		Dial, South.
	d. m.		d. m.		d. m.		d. m.		d. m.		d. m.		
	m.		m.		m.		m.		m.		m.		
27	6	36	14	41	24	35	38	11	59	27	90	00	63
28	7	10	15	10	25	9	39	7	60	17	90	00	62
29	7	24	15	40	25	53	40	2	61	4	90	00	61
30	7	58	16	6	26	33	40	54	61	49	90	00	60
31	7	50	16	34	27	15	41	44	62	30	90	00	59
32	8	5	17	11	27	55	42	30	63	11	90	00	58
33	8	19	17	27	28	34	43	20	63	49	90	00	57
34	8	31	17	54	29	13	44	5	64	24	90	00	56
35	8	44	18	20	29	50	44	45	64	58	90	00	55
36	8	57	18	45	30	27	43	31	65	30	90	00	54
37	9	10	19	9	31	2	46	12	66	10	90	00	53
38	9	22	19	34	31	37	46	50	66	29	90	00	52
39	9	34	19	58	32	11	47	28	66	56	90	00	51
40	9	45	10	21	32	44	48	7	67	21	90	00	50
41	9	57	20	44	33	16	48	39	67	47	90	00	49
42	10	10	21	7	33	46	49	12	68	11	90	00	48
43	10	22	21	29	34	18	49	44	68	33	90	00	47
44	10	32	21	51	34	47	50	10	68	54	90	00	46
45	10	43	22	12	35	17	50	46	69	15	90	00	45
46	10	54	22	23	35	44	51	15	69	35	90	00	44
47	11	05	22	53	36	11	51	42	69	53	90	00	43
48	11	17	23	13	36	37	52	9	70	11	90	00	42
49	11	29	23	33	37	3	52	35	70	28	90	00	41
50	11	35	23	52	37	28	53	00	70	43	90	00	40
51	11	45	24	9	37	52	53	24	70	59	90	00	39
52	11	55	24	27	38	15	53	46	71	13	90	00	38
53	12	5	24	43	38	37	54	18	71	28	90	00	37
54	12	13	25	2	38	58	54	29	71	41	90	00	36
55	12	22	25	18	39	19	54	49	71	54	90	00	35
56	12	32	25	34	39	40	55	9	72	5	90	00	34
57	12	40	25	50	39	59	55	28	72	17	90	00	33
58	12	48	26	5	40	81	55	45	72	28	90	00	32

Dist.	Horizontal		Dist.		Horizontal		Dist.		Horizontal		Dist.		Horizontal		Dist.
	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.			
59	13	46	26	20	40	36	56	3	72	38	90	00	31		
60	13	4	26	34	40	54	56	19	72	48	30	00	30		
61	13	11	26	47	41	10	56	34	72	58	90	00	29		
62	13	19	27	1	41	21	56	49	73	7	90	00	28		
63	13	26	27	13	41	43	57	3	73	15	90	00	27		
64	13	32	27	25	41	57	57	17	73	24	90	00	26		
65	13	39	27	37	42	15	57	30	73	32	90	00	25		
66	13	46	27	49	42	25	57	43	73	39	90	00	24		
67	13	51	27	59	42	38	57	54	73	46	90	00	23		
68	13	57	28	9	42	50	58	5	73	53	90	00	22		
69	14	3	28	19	43	2	58	16	73	59	90	00	21		
70	14	8	28	29	33	13	58	26	74	05	90	00	20		
71	14	13	28	27	43	18	58	35	74	11	90	00	19		
72	14	18	28	46	43	24	58	44	74	16	90	00	18		
73	14	22	28	54	43	36	58	52	74	20	90	00	17		
74	14	27	29	2	43	52	59	00	74	25	90	00	16		
75	14	30	29	7	44	00	59	7	74	30	90	00	15		
76	14	33	29	15	44	8	59	15	74	34	90	00	14		
77	14	37	29	21	44	14	59	22	74	37	90	00	13		
78	14	41	29	27	44	22	59	27	74	41	90	00	12		
79	14	44	29	32	44	28	59	32	74	44	90	00	11		
80	14	47	29	37	44	34	59	37	74	47	90	00	10		
81	14	49	29	41	44	37	59	40	74	49	90	00	9		
82	14	51	29	45	44	40	59	44	74	51	90	00	8		
83	14	53	29	49	44	44	59	47	73	53	90	00	7		
84	14	55	29	52	44	48	59	51	74	55	90	00	6		
85	14	56	29	54	44	53	59	54	74	57	90	00	5		
86	14	57	29	55	44	55	59	55	74	58	90	00	4		
87	14	58	29	56	44	56	59	56	74	58	90	00	3		
88	14	59	29	57	44	57	59	58	74	59	90	00	2		
89	14	59	29	58	44	58	59	59	74	59	90	00	1		
90	15	00	30	00	45	00	60	00	75	00	90	00			

A Table of Horizontal Spaces, Exactly Calculated for the Latitude of LONDON: Shewing what Angle, every Five Minutes makes with the Meridian, upon an Horizontal Dial.

Hours.	d.	m.	Hours.	d.	m.	Hours.	d.	m.
xii. 00	00	00	ii. 22	24	20	iv. viii.	53	36
9 55	00	59	9 55	25	25	5 55	54	39
10 50	1	58	10 50	26	30	10 50	56	23
15 55	2	57	15 45	27	37	15 45	57	48
20 40	3	55	20 40	28	44	20 40	59	14
25 35	4	54	25 35	29	51	25 35	60	40
30 30	5	53	30 30	30	59	30 30	62	10
35 25	6	52	35 25	32	00	35 25	63	35
40 20	7	51	40 20	33	18	40 20	65	4
45 15	8	51	45 15	34	29	45 15	66	34
50 10	9	51	50 10	35	40	50 10	68	4
55 05	10	51	55 5	36	51	55 5	69	35
ii. xi.	11	51	iii. ix.	38	4	vi. vii.	71	6
5 55	12	51	5 55	39	17	5 55	72	39
10 50	13	52	10 50	40	31	10 50	74	12
15 45	14	53	15 45	41	45	15 45	75	45
20 40	15	54	20 40	43	1	20 40	77	20
25 35	16	55	25 35	44	18	25 35	78	35
30 30	17	56	30 30	45	35	30 30	80	27
35 25	18	00	35 25	46	55	35 25	82	2
40 20	19	04	40 20	48	12	40 20	83	36
45 15	21	07	45 15	49	31	45 15	88	13
50 10	23	11	50 10	50	52	50 10	86	49
55 05	25	12	55 5	52	13	55 5	88	24
i. 00	00	00	vi. vi.	90	00			

*A Table showing
what Angle every
Hour, Quarter,
Half, and
Three Quarters of
an Hour, makes
in a Direct
South-Dial.*

Hours.	d.	m.
xii.	00	00
1.	3	21
2.	2	41
3.	1	7
iv.	xii.	9
5.	3	11
6.	2	14
7.	1	17
viii.	0	19
9.	3	22
10.	2	25
11.	1	28
xii.	0	31
1.	3	35
2.	2	39
3.	1	42
iv.	xii.	47
5.	3	51
6.	2	56
7.	1	61
viii.	0	66
9.	3	72
10.	2	78
11.	1	83
xii.	0	90

*A Table for East
and West-Dials*

Hours.	d.	m.
vi.	00	00
1.	3	3
2.	2	7
3.	1	11
iv.	0	15
v.	3	18
6.	2	22
7.	1	26
viii.	0	30
9.	3	33
10.	2	37
11.	1	41
xii.	0	45
1.	3	48
2.	2	52
3.	1	56
iv.	0	60
5.	3	63
6.	2	67
7.	1	72
viii.	0	75
9.	3	80
10.	2	84
11.	1	88
xii.	0	90

*A Table showing
what Angle every
Hour, Quarter,
Half, and Three
Quarters of an
Hour makes in a
Polar Dial.*

Hours.	d.	m.
xii.	00	00
1.	3	3
2.	2	7
3.	1	11
iv.	0	15
5.	3	18
6.	2	22
7.	1	26
viii.	0	30
9.	3	33
10.	2	37
11.	1	41
xii.	0	45
1.	3	58
2.	2	52
3.	1	56
iv.	0	60
5.	3	63
6.	2	67
7.	1	72
viii.	0	75
9.	3	78
10.	2	82
11.	1	86
xii.	0	90

A TABLE of Hour Distances, and Parts of an Hour from the Substile, in Declining Dials, in the Latitude 51 deg. 30 min.

South Declining 1. 00.			South Declining 2 00.			South Declining 3. 00.		
Hours.	d.	m.	Hours.	d.	m.	Hours.	d.	m.
vi.	93	28	vi.	94	06	vi.	96	06
1	3 86	2	1	3 86	28	1	3 90	06
2	2 80	4	2	2 80	24	2	2 84	05
3	3 74	14	3	1 76	11	3	1 78	09
vii.	v. 68	35	vii.	v. 70	27	vii.	v. 72	21
1	3 63	11	1	3 64	58	1	3 66	47
2	2 58	2	2	2 59	44	2	2 51	28
3	1 53	11	3	1 54	47	3	1 56	24
viii.	iv. 48	38	viii.	iv. 50	08	viii.	iv. 52	18
1	3 44	22	1	3 45	46	1	3 47	11
2	2 39	41	2	2 41	40	2	2 43	00
3	1 36	47	3	1 37	50	3	1 39	04
ix.	iii. 32	3	ix.	iii. 34	13	ix.	iii. 35	15
1	3 28	52	1	3 30	49	1	3 31	59
2	2 25	44	2	2 27	36	2	2 28	39
3	1 22	48	3	1 24	33	3	1 25	33
x.	ii. 20	43	x.	ii. 21	39	x.	ii. 22	36
1	3 17	59	1	3 18	42	1	3 19	48
2	2 15	20	2	2 16	13	2	2 17	05
3	1 12	47	3	1 13	38	3	1 14	29
xi.	i. 10	18	xi.	i. 10	38	xi.	i. 11	57
1	3 7	52	1	3 08	42	1	3 09	30
2	2 5	29	2	2 06	18	2	2 07	05
3	1 3	9	3	1 03	55	3	1 04	43
xii.	0	48	xii.	01	36	xii.	02	23
Sub-	stile		Sub-	stile		Sub-	stile	
1	3 1	52	1	3 00	55	1	3 00	03
2	3 3	53	2	2 03	05	2	2 02	18
3	1 6	14	3	1 05	26	3	1 04	38

(1)			(2)			(3)		
i	xi. 08	38	i	xi. 07	49	i	xi. 07	00
1	3 11	04	1	3 10	15	1	3 09	25
2	2 13	30	2	2 12	43	2	2 11	52
3	1 16	10	3	1 15	16	3	1 14	24
ii.	x. 18	50	ii.	x. 17	45	ii.	x. 17	00
1	3 21	36	1	3 20	39	1	3 19	41
2	2 24	30	2	2 23	30	2	2 22	30
3	1 22	05	3	1 27	01	3	1 25	27
iii.	ix. 30	45	iii.	ix. 29	39	iii.	ix. 28	32
1	3 34	09	1	3 33	00	1	3 31	48
2	2 37	45	2	2 36	32	2	2 35	16
3	1 41	46	3	1 40	15	3	1 38	56
iv.	viii. 45	41	iv.	viii. 44	17	iv.	viii. 42	52
1	3 50	07	1	3 48	33	1	3 47	02
2	2 54	04	2	2 53	05	2	2 51	30
3	1 59	58	3	1 57	55	3	1 56	14
v.	vii. 64	51	v.	vii. 63	03	v.	vii. 61	16
1	3 70	21	1	3 68	27	1	3 66	38
2	2 76	04	2	2 74	06	2	2 72	09
3	1 81	55	3	1 79	57	3	1 77	56
vi.	83	56	vi.	83	54	vi.	83	53
South Declining.			South Declining.			South Declining.		
04 00.			05 00.			06 00.		
Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
vi.	99	12	2 88	13	2	2 90	25	
1	3 92	12	1 82	11	3	1 84	12	
2	2 86	11	vii. v. 76	17	vii.	v. 78	14	
3	1 80	11	3 70	32	1	3 72	35	
vii.	v. 74	19	2 63	01	2	2 66	49	
1	3 68	40	1 59	47	3	1 61	28	
2	2 63	15	viii. iv. 54	49	viii.	iv. 56	25	
3	1 58	06	3 50	10	1	3 51	39	
viii.	iv. 53	14	2 45	44	2	2 47	10	
1	1 48	40	1 41	40	3	1 42	49	
2	2 44	24	ix. iii. 37	50	ix.	iii. 39	03	
3	1 40	23	3 34	19	1	3 35	02	

(4)			(5)			(6)		
1	136	372	130	492	231	54		
2	133	403	127	363	128	38		
3	129	444	124	324	125	22		
4	126	355	121	395	222	35		
5	122	352	118	532	219	47		
6	120	453	116	133	117	05		
7	118	004	113	364	114	30		
8	115	211	111	091	211	58		
9	112	492	208	492	209	34		
10	210	202	106	232	107	07		
11	207	55	xii.	03	xii.	04	45	
12	105	521	201	381	202	25		
xii.	08	11	Sub.	file.	200	06		
1	210	512	203	53	Sub.	file.		
Sub.	file.	3	103	013	102	14		
2	201	291	105	231	104	34		
3	202	491	207	451	206	56		
4	106	112	210	102	209	20		
5	208	442	112	382	112	46		
6	210	431	115	101	114	17		
7	113	301	217	481	216	52		
8	116	042	220	382	210	34		
9	018	442	129	222	225	32		
10	020	45	ix.	26	211	17		
11	113	361	219	501	218	28		
12	ix.	27	222	492	221	37		
1	530	383	126	203	125	04		
2	234	01	iv.	39	05	52		
3	137	371	244	651	242	39		
4	viii.	262	248	212	246	49		
5	245	313	153	543	251	16		
6	248	42	v.	57	44	01		
7	153	161	262	521	261	03		
8	vii.	282	268	162	266	22		
9	364	413	172	573	271	58		
10	270	11	59	46	277	46		
11	171	531	285	451	282	43		
12	082	48						

South Declining. 07 00			South Declining. 08 00			South Declining. 09 00		
Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
1	293	18	1	294	26	1	295	16
2	186	14	2	188	17	2	190	23
3	780	13	3	784	12	3	784	15
4	274	21	4	277	52	4	275	14
5	268	38	5	276	32	5	273	23
6	163	12	6	164	58	6	166	45
7	158	02	7	159	32	7	164	23
8	332	10	8	334	45	8	335	38
9	343	35	9	350	04	9	351	31
10	144	18	10	145	40	10	147	02
11	139	17	11	141	34	11	145	50
12	236	30	12	238	44	12	238	52
1	232	59	1	234	07	1	235	14
2	189	39	2	190	42	2	196	46
3	126	30	3	127	30	3	128	24
4	333	32	4	334	49	4	335	25
5	430	42	5	431	20	5	432	29
6	117	57	6	118	49	6	119	41
7	115	19	7	116	10	7	117	10
8	928	47	8	929	55	8	934	25
9	210	20	9	212	07	9	212	06
10	107	54	10	108	42	10	109	21
11	105	32	11	106	19	11	107	05
12	308	42	12	309	59	12	304	45
1	300	53	1	302	40	1	303	26
Sub-File.			Sub-File.			Sub-File.		
1	101	29	1	100	59	1	100	07
2	105	38	2	106	59	2	108	15
3	106	06	3	105	19	3	104	30
4	108	30	4	107	40	4	106	51
5	110	55	5	110	04	5	109	13
6	113	24	6	112	33	6	112	40
7	113	28	7	113	03	7	113	09
8	118	34	8	117	40	8	116	44
9	121	23	9	120	22	9	120	24

year (7) datus				year (8) datus				year (9) datus			
iii	ix	24	19	iii	ix	23	18	iii	ix	22	08
i		327	16	i		326	15	i		325	09
2		230	28	2		229	19	2		228	10
3		133	30	3		132	37	3		131	25
iv	viii	37	26	iv	viii	36	08	iv	viii	34	15
i		343	16	i		339	52	i		338	30
2		345	30	2		243	52	2		242	22
3		149	31	3		148	08	3		146	34
iv	vii	54	20	iv	vii	52	40	iv	vii	51	04
i		359	16	i		357	31	i		356	49
2		264	30	2		262	39	2		260	50
3		170	02	3		168	05	3		166	10
vi		75	45	vi		73	46	vi		71	46
i		340	81	i		379	38	i		377	36

South Declining. South Declining. South Declining.

10 00			11 00			21 00		
Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
301	192	23	301	194	25	301	196	35
viii	786	15	viii	788	17	vii	790	20
100	380	12	100	382	10	100	384	01
212	274	16	212	276	11	212	278	03
320	168	32	320	170	22	320	172	10
viii	1763	04	viii	1764	48	viii	1766	29
102	357	53	102	359	30	102	361	05
270	253	00	270	254	30	270	255	19
303	148	25	303	149	49	303	151	12
iii	144	07	iii	145	25	iii	146	42
i	340	06	i	341	19	i	342	30
212	236	21	212	237	59	212	238	36
301	132	49	301	133	53	301	134	56
x	129	28	x	130	30	x	131	28
20	326	22	20	327	38	20	328	14
21	223	24	21	224	18	21	225	11
22	120	34	22	121	25	22	122	06

((37))

(10)				(11)				(12)						
xi	i	17	15	xi	i	18	40	xi	i	19	19			
1		3	15	1		3	16	03	1		3	16	08	
2		2	12	43	2		2	13	30	2		2	14	16
3		1	10	16	3		1	11	02	3		1	11	47
	xii	07	52		xii	08	38		xii	09	23			
1		3	05	31	1		3	06	17	1		3	07	00
2		2	03	12	2		2	03	51	2		2	04	40
3		1	00	54	3		1	01	39	3		1	02	23
	Sub.		file.		Sub.		file.			Sub.		file.		
i		xi	01	25	i		xi	00	38	Sub.		file.		
1		3	03	43	1		3	02	57	1		3	02	11
2		2	06	02	2		2	05	15	2		2	04	29
3		1	08	24	3		1	07	35	3		1	06	48
ii		x	10	48	ii		x	09	59	ii		x	09	09
1		3	13	13	1		3	12	42	1		3	11	34
2		2	15	49	2		2	14	55	2		2	14	03
3		1	18	27	3		1	17	30	3		1	16	36
iii		ix	21	12	iii		ix	20	17	iii		ix	19	04
1		3	24	03	1		3	23	01	1		3	22	00
2		2	27	03	2		2	25	58	2		2	24	54
3		1	30	14	3		1	29	05	3		1	27	57
iv		viii	33	36	iv		viii	32	23	iv		viii	31	11
1		3	37	10	1		3	35	52	1		3	34	40
2		2	41	00	2		2	39	36	2		2	38	15
3		1	45	04	3		1	43	35	3		1	42	09
v		vii	49	26	v		vii	47	51	v		vii	46	20
1		3	54	04	1		3	52	37	1		3	50	49
2		2	49	02	2		2	57	16	2		2	55	32
3		1	64	17	3		1	62	16	3		1	60	37
	vi.		69	49		vi.		67	52		vi.		66	00
1		3	75	36	1		3	73	35	1		3	71	39
2		2	81	33	2		2	79	16	2		2	77	32

South Declining.			South Declining.			South Declining.		
13 00.			14 00.			15 00.		
Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
vii	196	43	vii	194	25	vii	196	28
vii	190	42	i	188	13	i	191	16
i	186	11	i	182	01	ii	184	02
ii	180	04	ii	175	58	ii	177	54
iii	174	05	iii	170	06	iii	171	56
iv	168	08	iv	164	20	iv	166	12
v	162	48	v	159	10	v	160	46
vi	157	35	vi	154	09	vi	155	38
vii	152	42	vii	149	27	vii	150	59
viii	148	04	viii	145	02	viii	146	21
ix	143	48	ix	140	58	ix	142	09
x	139	48	x	137	08	x	138	14
xi	136	02	xi	133	33	xi	134	35
xii	132	32	xii	130	11	xii	131	09
i	329	13	i	227	01	i	227	56
ii	226	06	ii	224	02	ii	224	53
iii	223	09	iii	221	11	iii	222	40
iv	220	21	iv	218	51	iv	219	15
v	217	38	v	215	21	v	216	37
vi	213	04	vi	212	20	vi	214	16
vii	212	27	vii	210	54	vii	211	38
viii	210	08	viii	208	31	viii	209	15
ix	207	47	ix	206	11	ix	206	55
x	205	27	x	203	54	x	204	37
xi	203	09	xi	201	36	xi	202	21
xii	202	53	xii	200	19	xii	200	05
Sub.	File.		Sub.	File.		Sub.	File.	
i	202	24	i	200	39	i	202	30
ii	203	41	ii	203	12	ii	204	26
iii	206	00	iii	207	31	iii	206	43
iv	208	20	iv	209	53	iv	209	04
v	310	42	v	212	18	v	211	27
vi	213	47	vi	214	47	vi	213	47
vii	215	40	vii	ix 17	20	vii	ix 16	25

(13)			(14)			(15)		
III	18	161	319	161	319	19	161	319
IV	21	002	322	002	322	21	002	322
V	23	503	324	503	324	23	503	324
VI	26	404	328	504	328	26	404	328
VII	30	005	330	005	330	30	005	330
VIII	33	201	333	201	333	33	201	333
IX	36	542	339	502	339	36	542	339
X	40	433	343	103	343	40	433	343
XI	44	431	347	304	347	44	431	347
XII	49	002	352	002	352	49	002	352
I	53	403	357	003	357	53	403	357
II	58	41	362	11	362	58	41	362
III	64	041	367	421	367	64	041	367
IV	69	392	373	202	373	69	392	373
V	77	043	377	503	377	77	043	377
South Declining			South Declining			South Declining		
16 90.			17 90.			18 100.		
Hours	D.	M.	Hours	D.	M.	Hours	D.	M.
VI	98	31	VII	100	33	VII	102	35
I	92	171	I	94	201	I	96	37
2	86	042	2	88	082	2	90	09
3	79	493	3	81	273	3	82	44
VIII	73	45	VIII	75	38	VIII	77	23
I	67	551	I	69	421	I	71	30
2	62	212	2	64	022	2	65	47
3	57	073	3	58	403	3	60	14
IV	52	112	IV	53	592	IV	55	04
I	47	361	I	48	501	I	50	16
2	43	181	2	44	332	2	45	49
3	39	191	3	40	203	3	41	30
IV	35	352	IV	36	392	IV	37	42
I	32	051	I	33	291	I	34	04
2	28	292	2	29	452	2	30	44
3	25	433	3	26	373	3	27	29

(16)			(17)			(18)		
xi	122	48	xi	123	36	xi	124	28
1	320	011	1	320	501	1	321	38
2	217	222	2	217	452	2	218	54
3	114	493	3	115	353	3	116	18
xii	12	32	xii	13	05	xii	13	49
1	309	571	1	310	411	1	311	24
2	207	372	2	208	212	2	209	02
3	105	143	3	106	053	3	106	44
xi	x104	041	xi	x102	371	xi	x104	29
1	300	491	1	301	321	1	302	16
Sub.	file.		Sub.	file.		Sub.	file.	
2	201	262	2	200	53	Sub.	file.	
3	103	403	3	102	563	3	102	12
ii	x05	571	ii	x05	111	ii	x04	25
1	308	151	1	307	281	1	306	12
2	210	362	2	209	472	2	208	59
3	113	003	3	112	103	3	111	20
ix	ix15	301	ix	ix14	371	ix	ix13	45
1	318	031	1	317	091	1	316	34
2	220	472	2	219	492	2	218	50
3	123	342	3	122	543	3	121	33
iv	viii26	331	iv	viii25	281	iv	viii24	24
1	329	411	1	328	331	1	327	34
2	233	012	2	231	482	2	230	35
3	136	342	3	135	543	3	133	58
v	vii40	221	v	vii38	591	v	vii37	36
1	344	261	1	342	581	1	341	29
2	248	482	2	247	532	2	245	40
3	153	393	3	151	493	3	150	01
vi	58	30	vi	56	44	vi	54	58
1	363	501	1	361	581	1	360	06
2	269	282	2	267	322	2	265	34
3	175	233	3	173	203	3	171	21

South Declining.			South Declining.			South Declining.		
19 00			20 00			21 00		
Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
1	3 58	28	1	3 100	31	1	3 102	39
2	2 92	07	2	2 96	16	2	2 96	14
3	1 85	44	3	1 83	47	3	1 89	48
viii	iv 79	28	viii	iv 81	25	viii	iv 83	22
1	3 73	19	1	3 71	11	1	3 77	02
2	2 67	26	2	2 69	10	2	2 70	55
3	1 61	50	3	1 63	27	3	1 63	04
ix	iii 56	32	ix	iii 57	21	ix	iii 59	32
1	3 51	37	1	3 53	00	1	3 54	32
2	2 47	00	2	2 48	16	2	2 49	31
3	1 42	44	3	1 43	45	3	1 45	02
4	1 38	45	4	1 39	50	4	1 40	53
1	3 35	02	1	3 36	02	1	3 37	01
2	2 31	35	2	2 32	31	2	2 33	25
3	1 28	20	3	1 29	12	3	1 30	03
xi	0 35	17	xi	1 26	06	xi	1 26	51
1	3 12	23	1	3 23	10	1	3 23	56
2	2 17	39	2	2 20	24	2	2 21	08
3	1 19	02	3	1 17	45	3	1 18	38
xii	14	31	xii	15	13	xii	15	54
1	3 12	00	1	3 12	47	1	3 13	26
2	2 09	44	2	2 13	25	2	2 11	04
3	1 07	26	3	1 08	07	3	1 08	33
04	xi 05	11	04	xi 05	52	04	xi 06	32
1	3 02	59	1	3 03	37	1	3 04	18
2	2 00	44	2	2 01	26	2	2 02	27
Sub.	file.		Sub.	file.		Sub.	file.	
3	1 01	28	3	1 00	46	3	1 00	04
ii	2 03	41	ii	1 02	58	ii	1 02	14
1	1 05	56	1	3 05	10	1	3 04	27
2	2 08	12	2	2 07	25	2	2 06	40
3	1 10	31	3	1 09	43	3	1 08	55
iii	ix 12	53	iii	ix 12	03	iii	ix 11	13
1	3 15	41	1	3 14	28	1	3 13	36

South Declining			South Declining			South Declining		
22 00			23 10			24 00		
Hours	D.	M.	Hours	D.	M.	Hours	D.	M.
21	3105	15	2106	38	2	3100	25	
20	2108	16	2100	23	3	2105	56	
19	1101	49	1103	54	viii	1109	21	
viii	1105	20	1107	25	1	1102	47	
18	3178	56	3180	52	2	3176	30	
17	2172	42	2174	33	3	2170	07	
16	3166	49	3168	25	4	3164	12	
xv	1161	04	1162	38	1	1158	38	
15	3155	46	3154	13	2	3153	26	
14	2150	49	2152	08	3	2148	37	
13	1146	14	1147	25	2	1144	08	
xii	3141	58	3143	03	2	3139	49	
12	3138	01	3139	00	2	3136	41	
11	2134	20	2135	10	3	2132	37	
10	1130	55	1131	46	1	1129	19	

(22)		(23)		(24)	
1	127	43	128	91	926
2	324	42	325	282	223
3	221	52	222	313	220
9	129	103	119	51	xii 17
xii	16	30	xii 17	103	235
1	314	07	314	47	213
2	311	44	212	223	110
3	109	26	110	04	208
4	207	10	207	49	905
5	304	57	305	37	204
6	202	40	203	26	101
7	100	30	101	16	Sub. file.
Sub.	file.	Sub.	file.	100	13
1	201	34	200	51	302
2	304	38	303	01	204
3	205	50	205	09	106
4	108	10	107	20	108
iii	210	26	iii 26	39	311
1	312	47	311	57	213
2	215	12	214	23	115
3	117	43	116	47	viii 18
iv	viii 20	19	iv viii 19	21	311
1	323	06	322	03	213
2	226	00	224	52	116
3	129	06	127	95	vii 19
v	vii 22	24	vii 31	08	333
1	331	53	334	34	236
2	239	43	238	17	140
3	143	48	142	15	vi 44
vi	48	12	vi 46	33	349
1	351	57	351	12	234
2	258	63	256	12	139
3	163	31	161	34	vii 16
vii	169	18	vii 16	18	371

South Declining. 25 00.			South Declining. 26 00.			South Declining. 27 00		
Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
2	2 103	28	2	2 106	33	1	3 108	35
3	1 98	00	3	1 100	06	2	2 102	19
viii	iv 91	47	viii	iv 94	21	viii	iv 95	31
1	3 84	45	1	3 86	45	1	3 88	46
2	2 78	19	2	2 81	53	2	3 82	02
3	1 71	53	3	1 73	43	3	1 75	28
ix	iii 65	49	ix	iii 67	27	ix	iii 69	09
1	3 60	07	1	3 62	10	1	3 63	10
2	2 54	48	2	2 56	08	2	2 57	33
3	1 49	51	3	1 51	04	3	1 52	20
x	ii 45	16	x	ii 46	22	x	ii 47	31
1	3 41	02	1	3 42	02	1	3 42	50
2	2 37	08	2	2 38	02	2	2 38	58
3	1 33	30	3	1 34	19	3	1 35	12
xi	i 30	07	xi	i 30	53	xi	i 31	41
1	3 26	58	1	3 27	43	1	3 28	27
2	2 24	00	2	2 24	42	2	2 25	24
3	1 21	16	3	1 21	53	3	1 22	28
xii	18	33	xii	19	13	xii	19	51
1	3 16	04	1	3 16	02	1	3 16	39
2	2 13	39	2	2 13	37	2	2 14	14
3	1 11	20	3	1 11	19	3	1 12	31
i	x 09	04	i	x 09	40	i	x 10	16
1	3 06	52	1	3 07	38	1	3 08	03
2	2 04	42	2	2 05	19	2	2 06	55
3	1 02	34	3	1 03	11	3	1 02	47
ii	x 00	02	ii	x 01	05	ii	x 01	40
Sub.	stile.		Sub.	stile.		Sub.	stile.	
1	3 01	40	1	3 01	01	1	3 01	23
2	2 03	47	2	2 02	33	2	2 02	28
3	1 05	58	3	1 05	15	3	1 05	34
iii	ix 08	08	iii	ix 07	24	iii	ix 07	42
1	3 10	22	1	3 09	55	1	3 09	51
2	2 12	41	2	2 11	51	2	2 11	09
3	1 15	03	3	1 14	11	3	1 13	22

(23)				(26)				(27)			
iv	viii	17	31	iv	viii	16	36	iv	viii	35	46
1	3	20	32	1	3	19	08	1	3	18	13
2	2	22	44	2	2	21	47	2	2	20	50
3	1	15	47	3	1	24	36	3	1	23	34
v	vii	18	49	v	vii	27	36	v	vii	26	29
1	3	32	03	1	3	30	47	1	3	29	36
2	2	35	34	2	2	34	13	2	2	32	57
3	1	39	29	3	1	37	54	3	1	36	32
vi	4	43	28	vi	4	41	54	vi	4	40	26
1	3	47	54	1	3	47	26	1	3	45	50
2	2	52	41	2	2	52	13	2	2	50	31
3	1	57	51	3	1	57	24	3	1	54	11
vii	v	63	24	vii	v	61	26	vii	v	59	33
1	2	69	18	1	2	67	16	1	2	65	19

South Declining			South Declining			South Declining					
28 00			29 00			30 00					
Hours.	d.	m.	Hours.	d.	m.	Hours.	d.	m.			
3	i	104	153	1	106	213	1	108	25		
viii.	iv.	97	36	viii.	iv.	99	41	viii.	iv.	101	47
1	3	91	20	1	3	92	17	1	3	94	55
2	2	84	01	2	2	86	00	2	2	88	00
3	1	77	19	3	1	79	12	3	1	81	05
ix.	iii.	70	52	ix.	iii.	72	36	ix.	iii.	74	21
1	3	64	43	1	3	66	18	1	3	67	55
2	2	58	58	2	2	60	24	2	2	61	52
3	1	53	37	3	1	54	54	3	1	56	16
x.	ii.	48	40	x.	ii.	49	50	x.	ii.	51	00
1	3	44	07	1	3	45	09	1	3	46	12
2	2	39	57	2	2	40	52	2	2	41	48
3	1	36	04	3	1	36	55	3	1	37	46
xi.	i.	32	26	xi.	i.	33	16	xi.	i.	34	02
1	3	29	10	1	3	29	50	1	3	30	37
2	2	26	06	2	2	26	38	2	2	27	26
3	1	23	12	3	1	23	50	3	1	24	27

(38)			(39)			(30)		
xii	30	29	xii	31	05	xii	31	49
17	317	55	18	30	1	19	04	
18	315	27	15	59	4	15	38	
19	318	04	13	49	3	14	19	
20	310	51	11	24	1	11	52	
21	308	38	09	13	1	09	44	
22	306	30	07	03	2	07	36	
23	304	04	04	58	2	05	32	
24	302	19	02	54	1	02	28	
25	300	19	00	54	1	01	26	
Sub	file.		Sub	file.		Sub	file.	
26	291	49	01	11	3	00	33	
27	293	54	03	14	3	02	37	
28	295	00	05	18	3	04	39	
29	298	08	07	25	1	06	43	
30	290	18	09	24	2	08	50	
31	282	33	11	46	3	11	00	
32	274	59	13	03	4	13	04	
33	267	18	16	23	1	15	34	
34	259	51	18	54	2	18	00	
35	252	33	21	32	3	20	34	
36	245	23	24	18	4	23	16	
37	238	21	27	16	1	26	09	
38	231	41	30	23	2	29	15	
39	225	11	33	51	3	32	34	
40	218	52	37	32	4	36	09	
41	211	05	41	34	1	40	03	
42	204	31	45	54	2	44	18	
43	197	24	50	38	3	48	56	
44	190	39	55	47	4	53	58	
45	183	19	61	20	1	54	25	
46	176	22	67	19	2	55	59	

South Declining			South Declining			South Declining		
31.00			32.00			33.00		
Hour.	d.	m.	Hour.	d.	m.	Hour.	d.	m.
vi.	110	59	vi.	112	58	viii.	108	57
viii.	103	58	viii.	106	57	ix.	101	56
x.	97	57	x.	99	56	x.	94	55
xii.	90	56	xii.	92	55	xi.	87	54
i.	83	55	i.	85	54	xii.	79	53
ii.	76	54	ii.	78	53	i.	72	52
iii.	69	53	iii.	71	52	ii.	66	51
iv.	63	52	iv.	64	51	iii.	60	50
v.	57	51	v.	58	50	iv.	54	49
vi.	52	50	vi.	53	49	v.	49	48
vii.	47	49	vii.	48	48	vi.	44	47
viii.	42	48	viii.	43	47	vii.	41	46
ix.	38	47	ix.	39	46	viii.	36	45
x.	34	46	x.	35	45	ix.	32	44
xi.	30	45	xi.	31	44	x.	29	43
xii.	26	44	xii.	27	43	xi.	25	42
i.	22	43	i.	23	42	xii.	22	41
ii.	18	42	ii.	19	41	i.	19	40
iii.	15	41	iii.	16	40	ii.	16	39
iv.	12	40	iv.	13	39	iii.	13	38
v.	9	39	v.	10	38	iv.	10	37
vi.	7	38	vi.	8	37	v.	8	36
vii.	4	37	vii.	5	36	vi.	5	35
viii.	2	36	viii.	3	35	vii.	3	34
ix.	0	35	ix.	1	34	viii.	1	33
x.	0	34	x.	0	33	ix.	0	32
xi.	0	33	xi.	0	32	x.	0	31
xii.	0	32	xii.	0	31	xi.	0	30
i.	0	31	i.	0	30	xii.	0	29
ii.	0	30	ii.	0	29	i.	0	28
iii.	0	29	iii.	0	28	ii.	0	27
iv.	0	28	iv.	0	27	iii.	0	26
v.	0	27	v.	0	26	iv.	0	25
vi.	0	26	vi.	0	25	v.	0	24
vii.	0	25	vii.	0	24	vi.	0	23
viii.	0	24	viii.	0	23	vii.	0	22
ix.	0	23	ix.	0	22	viii.	0	21
x.	0	22	x.	0	21	ix.	0	20
xi.	0	21	xi.	0	20	x.	0	19
xii.	0	20	xii.	0	19	i.	0	18
i.	0	19	i.	0	18	ii.	0	17
ii.	0	18	ii.	0	17	iii.	0	16
iii.	0	17	iii.	0	16	iv.	0	15
iv.	0	16	iv.	0	15	v.	0	14
v.	0	15	v.	0	14	vi.	0	13
vi.	0	14	vi.	0	13	vii.	0	12
vii.	0	13	vii.	0	12	viii.	0	11
viii.	0	12	viii.	0	11	ix.	0	10
ix.	0	11	ix.	0	10	x.	0	9
x.	0	10	x.	0	9	xi.	0	8
xi.	0	9	xi.	0	8	xii.	0	7
xii.	0	8	xii.	0	7	i.	0	6
i.	0	7	i.	0	6	ii.	0	5
ii.	0	6	ii.	0	5	iii.	0	4
iii.	0	5	iii.	0	4	iv.	0	3
iv.	0	4	iv.	0	3	v.	0	2
v.	0	3	v.	0	2	vi.	0	1
vi.	0	2	vi.	0	1	vii.	0	0
vii.	0	1	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.	0	0
v.	0	0	v.	0	0	vi.	0	0
vi.	0	0	vi.	0	0	vii.	0	0
vii.	0	0	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.	0	0
v.	0	0	v.	0	0	vi.	0	0
vi.	0	0	vi.	0	0	vii.	0	0
vii.	0	0	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.	0	0
v.	0	0	v.	0	0	vi.	0	0
vi.	0	0	vi.	0	0	vii.	0	0
vii.	0	0	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.	0	0
v.	0	0	v.	0	0	vi.	0	0
vi.	0	0	vi.	0	0	vii.	0	0
vii.	0	0	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.	0	0
v.	0	0	v.	0	0	vi.	0	0
vi.	0	0	vi.	0	0	vii.	0	0
vii.	0	0	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.	0	0
v.	0	0	v.	0	0	vi.	0	0
vi.	0	0	vi.	0	0	vii.	0	0
vii.	0	0	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.	0	0
v.	0	0	v.	0	0	vi.	0	0
vi.	0	0	vi.	0	0	vii.	0	0
vii.	0	0	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.	0	0
v.	0	0	v.	0	0	vi.	0	0
vi.	0	0	vi.	0	0	vii.	0	0
vii.	0	0	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.	0	0
v.	0	0	v.	0	0	vi.	0	0
vi.	0	0	vi.	0	0	vii.	0	0
vii.	0	0	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.	0	0
v.	0	0	v.	0	0	vi.	0	0
vi.	0	0	vi.	0	0	vii.	0	0
vii.	0	0	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.	0	0
v.	0	0	v.	0	0	vi.	0	0
vi.	0	0	vi.	0	0	vii.	0	0
vii.	0	0	vii.	0	0	viii.	0	0
viii.	0	0	viii.	0	0	ix.	0	0
ix.	0	0	ix.	0	0	x.	0	0
x.	0	0	x.	0	0	xi.	0	0
xi.	0	0	xi.	0	0	xii.	0	0
xii.	0	0	xii.	0	0	i.	0	0
i.	0	0	i.	0	0	ii.	0	0
ii.	0	0	ii.	0	0	iii.	0	0
iii.	0	0	iii.	0	0	iv.	0	0
iv.	0	0	iv.	0	0	v.</		

(31)				(32)				(33)			
iv	viii	12	28	iv	viii	11	41	iv	viii	13	08
1		3 14	44	1		3 13	55	1		3 15	18
2		2 17	07	2		2 16	19	2		2 17	47
3		1 19	37	3		1 18	41	3		1 20	17
v	vii	22	15	v	vii	21	15	v	vii	22	58
1		3 25	04	1		3 22	00	1		3 25	49
2		2 28	04	2		2 26	56	2		2 28	52
3		1 31	18	3		1 30	04	3		1 32	11
vi		34	48	vi		33	29	vi		35	46
1		3 38	36	1		3 38	19	1		3 39	40
2		2 42	43	2		2 41	12	2		2 43	57
3		1 47	15	3		1 45	25	3		1 48	38
vii	v	52	09	vii	v	50	24	vii	v	55	09
1		3 57	31	1		3 45	30	1		3 59	21
2		2 63	19	2		2 61	20	2		2 65	25

South Declining. South Declining. South Declining.

34 00. 35 00. 36 00.

Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
viii. iv.	110	14	viii. iv.	112	18	viii. iv.	114	22
1	3 103	25	1	3 105	27	1	3 107	40
2	2 96	19	2	2 98	25	2	2 100	34
3	1 89	04	3	1 91	17	3	1 93	12
ix. iii.	81	50	ix. iii.	83	47	ix. iii.	85	46
1	3 74	48	1	3 76	37	1	3 78	26
2	2 68	04	2	2 69	42	2	2 71	31
3	1 61	46	3	1 63	14	3	1 64	47
x. ii.	55	56	x. ii.	57	13	x. ii.	58	32
1	3 50	35	1	3 51	42	1	3 52	54
2	2 45	42	2	2 46	41	2	2 47	39
3	1 41	14	3	1 42	07	3	1 43	00
vii. v.	37	10	vii. v.	37	57	vii. v.	38	43
1	3 33	28	1	3 34	09	1	3 34	50
2	2 30	03	2	2 30	41	2	2 31	48
3	1 26	54	3	1 27	29	3	1 28	03
xii.	23	56	xii.	24	31	xii.	25	04

(34)			(35)			(36)		
1	321	161	321	461	322	16		
2	218	412	219	123	217	40		
3	116	173	116	463	117	13		
i	xi14	001	xi14	241	xi14	54		
1	311	471	312	151	312	42		
2	209	402	210	082	210	31		
3	107	363	108	053	106	32		
ii	x05	36ii	x06	06ii	x08	32		
1	303	381	304	081	306	33		
2	201	412	202	192	204	37		
Sub.	file.	3	100	183	100	49		
3	100	15	Sub.	file.	Sub.	file.		
iii	ix02	11iii	ix01	37iii	ix01	05		
1	304	091	303	341	302	58		
2	206	072	205	302	204	53		
3	108	083	107	293	106	50		
iv	viii10	12iv	viii09	31iv	viii08	49		
1	312	211	311	361	310	52		
2	214	342	213	472	213	00		
3	116	543	115	043	115	13		
v	vii19	21v	vii18	27v	vii17	33		
1	321	571	320	581	320	00		
2	224	432	223	402	222	38		
3	127	103	126	343	125	27		
vi.	30	54	vi.	29	41	29		
1	333	561	333	041	331	46		
2	238	112	236	462	235	21		
3	142	203	140	493	139	17		
vii	v46	55vii	v45	15vii	v43	36		
1	351	551	350	181	348	12		
2	257	242	255	302	253	36		
3	164	193	163	213	159	41		

South Declining.			South Declining.			South Declining.		
37 00.			38 00.			39 00.		
Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
i	3109	41 i	3112	01 i		3114	29	
2	3102	45 2	3104	57 2		3107	08	
3	3095	21 3	3097	33 3		3099	43	
4	3087	49 ix	3089	56 ix		3091	52	
5	3080	21 i	3082	20 i		3084	18	
6	3073	06 2	3074	55 2		3076	43	
7	3066	15 3	3067	52 3		3069	28	
8	3059	53 x	3061	17 x		3062	42	
9	3054	02 i	3055	15 i		3056	29	
10	3048	42 2	3049	46 2		3050	44	
11	3043	52 3	3044	49 3		3045	28	
12	3039	30 xi	3040	18 xi		3041	06	
1	3035	32 i	3036	15 i		3036	56	
2	3031	55 2	3032	33 2		3033	06	
3	3028	37 3	3029	11 3		3029	44	
4	3025	35 3	3026	04 3		3026	35	
5	3022	29 i	3023	15 i		3023	43	
6	3020	06 2	3020	36 2		3021	03	
7	3017	40 3	3018	07 3		3018	31	
8	3015	21 i	3015	47 i		3016	12	
9	3013	09 i	3013	34 i		3013	59	
10	3011	02 2	3011	28 2		3011	52	
11	3009	00 3	3009	26 3		3009	51	
12	3007	01 ii	3007	08 ii		3007	53	
1	3005	05 i	3005	34 i		3005	58	
2	3003	12 2	3003	41 2		3004	00	
3	3001	20 3	3001	50 3		3002	18	
Sub.	file.		Sub.	file.		Sub.	file.	
4	3000	31 iii	3000	01 iii		3000	28	
5	3002	24 i	3001	52 i		3001	20	
6	3004	17 2	3003	53 2		3003	10	
7	3006	13 3	3005	35 3		3005	00	
8	3008	10 iv	3007	30 iv		3006	53	
9	3010	10 i	3009	28 i		3008	49	

(37)			(38)			(39)		
2	211	142	2	11	002	2	10	48
3	414	243	1	13	373	1	12	52
v	vii. 16	41v	vii. 15	31v	vii. 15	01		
1	319	401	2	18	091	3	17	18
2	221	382	2	20	392	2	19	49
3	124	213	1	23	183	1	22	17
vi	27	18	vi.	26	09	vi.	25	03
1	320	291	3	29	151	3	28	03
2	233	512	2	32	372	2	31	20
3	137	473	1	35	193	1	34	54
vii	v. 42	00vii	v. 40	33vii	v. 38	51		
1	346	361	3	44	531	3	43	14
2	251	432	2	49	522	2	48	05
3	157	213	1	55	213	1	53	27
viii	iv. 63	30viii	iv. 62	24viii	iv. 59	22		
South Declining			South Declining			South Declining		
46 00.			47 00			48 00.		
Hour.	D.	M.	Hour.	D.	M.	Hour.	D.	M.
1	3116	162	2	111	312	2	113	45
2	2111	573	1	104	093	1	166	17
3	1108	56x	ii	96	22x	ii	98	02
ix	ii. 94	161	3	88	151	3	90	31
1	286	102	2	79	182	2	82	28
2	278	353	1	72	383	1	74	37
3	171	10x	ii	65	24x	ii	67	12
x	ii. 64	101	3	58	461	3	60	21
1	357	442	2	52	442	2	54	07
2	251	543	1	47	193	1	48	30
3	146	42xi	1	42	27xi	1	43	20
xl	i. 44	531	3	38	061	3	27	52
1	337	372	2	34	102	2	34	38
2	253	453	1	30	363	1	31	19
3	130	16	xii	27	33	xii	28	01
xii	27	031	3	24	301	3	25	00

	(40)			(41)			(42)		
1	3 24	102		2 11	46 2		2 22	15	
2	2 21	27 1		3 19	11 3		1 19	43	
3	1 18	57 1		x 16	53 1		x 17	22	
1	x 16	36 1		3 14	37 1		3 15	03	
1	3 14	22 2		2 12	35 2		2 12	59	
2	2 12	16 3		1 10	34 3		1 10	59	
3	1 10	14 11		x 08	38 11		x 09	02	
ii.	x 08	17 1		3 06	46 1		3 07	11	
1	3 06	28 2		2 04	53 2		2 05	23	
2	2 04	34 3		1 03	11 3		1 03	36	
3	1 02	45 11		ix 01	25 11		ix 01	51	
iii.	ix 00	58	Sub.	file.	1		3 00	03	
	Sub.	file.	1	3 00	21	Sub.	file.		
1	3 00	49 2		2 02	07 2		2 02	34	
2	2 02	38 3		1 03	54 3		1 03	22	
3	1 04	27 1v.	viii 05	42 1v.	viii 05		3 06	57	
iv.	viii 06	27 1		3 07	32 1		2 08	43	
1	3 08	10 2		2 09	26 2		1 10	42	
2	2 10	07 3		1 11	24 3		2 12	43	
3	1 12	08 1v.	vii 13	27 1v.	vii 12		3 14	49	
v.	vii 14	14 1		3 15	37 1		2 17	01	
1	3 16	27 2		2 17	53 2		1 19	23	
2	2 18	46 3		1 20	19 3		vi 21	54	
3	1 21	17	vi 22	57			3 24	38	
vi.	23	59 1		3 25	42 1		2 27	37	
1	3 26	21 2		2 28	48 2		1 30	32	
2	2 30	03 3		1 32	10 3		v 34	26	
3	1 33	31 1vii		v 35	52 1vii		3 38	25	
vii	v 37	21 1		3 39	58 1		2 42	51	
1	3 41	35 2		2 44	33 2		1 47	49	
2	2 46	18 3		1 49	38 3		iv 53	20	
3	1 51	33 1viii		iv 55	19 1viii		3 59	39	
viii	iv 57	20 1		3 61	35 1				

South Declining.			South Declining.			South Declining.		
43 00			44 00			45 00		
Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
iii ix	100	54	ix iii	103	10	ix iii	105	19
1	3 92	45	1	3 94	56	1	3 97	23
2	2 84	31	2	2 86	29	2	2 88	39
3	1 76	28	3	1 78	10	3	1 80	25
ii	x 68	48	ii	x 70	15	ii	x 72	27
1	3 61	36	1	3 62	58	1	3 64	27
2	2 55	19	2	2 56	13	2	2 57	29
3	1 49	30	3	1 50	23	3	1 51	30
xi	1 44	19	xi	1 44	58	xi	1 45	58
1	3 40	00	1	3 40	12	1	3 40	57
2	2 35	34	2	2 35	58	2	2 36	36
3	1 31	46	3	1 32	13	3	1 32	44
xii	28	29	xii	28	55	xii	29	21
1	3 25	17	1	3 25	40	1	3 26	02
2	2 22	40	2	2 22	52	2	2 23	29
3	1 20	06	3	1 20	17	3	1 20	44
xi	xi 17	34	xi	xi 17	51	xi	xi 18	19
1	3 15	21	1	3 15	25	1	3 15	59
2	2 13	14	2	2 13	34	2	2 13	58
3	1 11	29	3	1 11	35	3	1 12	00
ii	x 09	25	ii	x 09	41	ii	x 10	03
1	3 07	35	1	3 07	56	1	3 08	18
2	2 05	54	2	2 06	18	2	2 06	30
3	1 04	36	3	1 04	30	3	1 04	47
iii	ix 02	17	iii	ix 02	40	iii	ix 02	26
1	3 00	34	1	3 01	08	1	3 01	25
Sub.	File.		Sub.	File.		Sub.	File.	
2	2 01	07	2	2 00	46	2	2 00	15
3	1 02	51	3	3 02	34	3	3 01	53
iv	viii 04	38	iv	viii 04	20	iv	viii 03	34
1	3 06	24	1	3 06	00	1	3 05	15
2	2 08	15	2	2 07	40	2	2 06	59
3	1 10	04	3	1 09	28	3	1 08	30
v	vii 11	59	v	vii 11	20	v	vii 10	37
1	3 14	02	1	3 13	19	1	2 12	21

(43)			(44)			(45)		
2	216	112	215	192	717	03		
3	118	283	17	373	119	10		
vi	20	55	vi	19	36	01		
i	323	321	22	301	221	28		
2	226	342	25	182	224	09		
3	129	323	28	203	127	05		
vii	293	08	vii	31	38	20		
i	286	521	35	261	283	54		
2	241	102	39	332	237	58		
3	145	583	44	143	142	26		
viii	1751	32	viii	49	29	31		
South Declining.			South Declining.			South Declining.		
46 00			47 00			48 00		
Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
3	116	39	3	116	57	3	117	06
ix	108	50	ix	109	09	ix	117	36
i	299	34	i	101	51	i	104	21
2	290	58	2	293	21	2	295	35
3	186	20	3	184	25	3	186	38
x	72	58	x	75	56	x	77	45
xi	266	10	xi	267	31	xi	269	22
2	258	58	2	260	12	2	261	39
3	153	09	3	153	58	3	154	44
xi	146	42	xi	147	39	xi	148	36
i	341	41	i	343	22	i	343	19
2	437	18	2	437	51	2	438	28
3	133	19	3	133	50	3	134	18
xii	29	46	xii	30	11	xii	30	35
i	326	35	i	325	56	i	327	17
2	223	41	2	224	00	2	224	19
3	121	03	3	121	20	3	121	38
i	118	37	i	118	52	i	119	09
2	316	21	2	316	23	2	316	53
3	214	15	3	214	32	3	214	47

(46)				(47)				(48)			
3	112	153	3	112	393	712	47	3	112	47	
ii	110	2111	ii	110	3711	ix	110	55			
i	308	321	i	308	508	309	07				
3	206	482	3	207	072	207	24				
3	105	063	3	105	503	105	42				
ii	ix	03	26ii	ix	03	47ii	ix	04	08		
i	301	461	i	302	121	302	38				
3	200	102	3	200	353	200	58				
Sub.		file.	Sub.		file.	Sub.		file.			
3i	101	273	3i	101	013	100	23				
iv.	viii	03	03	iv.	viii	02	30iv	yii	02	09	
i	304	481	i	304	131	1303	45				
3	206	252	3	205	522	205	21				
3	108	102	3	107	3330	106	59				
vi	viii	09	57vi	viii	09	18v7	viii	08	42		
3	311	491	3	311	0610	310	28				
3	1213	4621	3	1213	0311	1212	19				
3	1115	523	3	1115	0034	1114	16				
vi.	18	061	vi.	17	130	vi.	16	21			
3	10320	291	3	10319	271	0318	35				
3	223	0522	3	223	0022	221	00				
3	1125	5937	3	1124	443	1123	38				
vii	iv	29	20vii	iv	27	42vii	v	26	32		
3	332	3031	3	331	341	329	43				
2.	311236	322	311235	0031	233	21					
3	1140	4331	3	1139	003	1137	24				
viii	iv	45	38viii	iv	43	54viii	iv	41	54		
South Declining.				South Declining.				South Declining.			
40 00.				50 00.				60 35 00.			
Hours.	D.	M.		Hours.	D.	M.		Hours.	D.	M.	
ix	iii	15	10	ix	iii	17	22	ix	iii	18	00
10	3	107	46	10	3	109	14	10	3	111	43
11	2	97	50	11	2	91	08	11	2	100	52
12	1	88	53	12	1	81	48	12	1	93	27

(49)			(50)			(51)		
x	ii	79 43	x	ii	81 48	x	ii	83 15
1		371 04	1		372 49	1		374 57
2		263 02	2		264 30	2		265 59
3		155 47	3		157 02	3		158 14
xi		149 30	xi		150 25	xi		151 20
1		343 52	1		344 40	1		345 22
2		239 03	2		239 35	2		240 07
3		134 46	3		135 13	3		135 40
xii		30 58	xii		31 21	xii		31 45
1		327 36	1		327 55	1		328 13
2		224 36	2		224 52	2		225 03
3		121 54	3		122 07	3		122 18
i	xi	19 23	i	xi	19 36	i	xi	19 49
1		317 02	1		317 20	1		317 32
2		214 59	2		215 11	2		215 25
3		113 01	3		113 14	3		113 23
ii	x	11 13	ii	x	11 27	ii	x	11 36
1		309 20	1		309 46	1		309 57
2		207 40	2		207 57	2		208 12
3		106 21	3		106 27	3		106 41
ix	iii	04 30	ix	iii	04 54	ix	iii	04 59
1		302 53	1		303 12	1		303 30
2		201 19	2		201 41	2		201 59
Sub.	file.	13	Sub.	file.	100	Sub.	file.	100
3		100 15	Sub.	file.	103	Sub.	file.	100
iv	viii	01 47	iv	viii	01 19	iv	viii	00 58
1		303 18	1		302 50	1		302 25
2		205 00	2		204 22	2		203 45
3		106 27	3		105 56	3		105 27
v	vii	08 00	v	vii	07 32	v	vii	07 00
1		309 49	1		309 12	1		308 36
2		211 37	2		210 57	2		210 18
3		113 32	3		112 47	3		112 05
vi.		15 32	vi.		15 03	vi.		14 04
1		317 42	1		316 49	1		315 59
2		220 01	2		219 03	2		218 08
3		123 01	3		121 30	3		120 29
vii	v	24 37	vii	v	24 11	vii	v	23 02

(49)			(50)			(51)		
1	3 28	27 1	3 27	10 1	3 25	59		
2	2 31	55 2	2 30	29 2	2 27	07		
3	1 35	49 3	1 34	14 3	1 32	43		
viii	iv 40	11 viii	iv 37	56 viii	iv 36	56		
South Declining			South Declining			South Declining		
52 00			53 00			54 00		
Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
1	3 117	21 1	3 118	16 1	3 119	08		
2	2 106	17 2	2 108	05 2	2 110	46		
3	1 96	57 3	1 98	39 3	1 101	06		
x	ii 86	09 x	ii 88	39 x	ii 90	46		
i	3 76	27 1	3 78	29 1	3 80	40		
2	2 67	29 2	2 69	30 2	2 71	00		
3	1 59	22 3	1 60	40 3	1 62	05		
xi	1 52	10 xi	1 55	20 xi	1 56	26		
i	3 45	57 1	3 46	41 1	3 48	15		
2	2 40	40 2	2 41	10 2	2 42	30		
3	1 35	58 3	1 36	30 3	1 37	45		
xii	32	05 xii	32	26 xii	32	46		
i	3 28	24 1	3 28	39 1	3 28	56		
2	2 25	13 2	2 25	25 2	2 25	40		
3	1 22	24 3	1 22	36 3	1 22	50		
i	xi 19	53 1	xi 20	12 1	xi 20	22		
1	3 17	38 1	3 17	45 1	3 17	56		
2	2 15	39 2	2 15	41 2	2 15	49		
3	1 13	35 3	1 13	43 3	1 13	59		
ii	x 11	48 1	x 11	57 1	x 12	06		
i	3 10	00 1	3 10	08 1	3 10	21		
2	2 08	21 2	2 08	38 2	2 08	43		
3	1 06	44 3	1 07	00 3	1 07	16		
iii	ix 05	18 1	ix 05	31 1	ix 05	44		
i	3 03	47 1	3 04	18 1	3 02	15		
2	2 02	18 2	2 02	35 2	2 02	52		
3	1 00	52 3	1 01	11 3	1 01	39		
Sub.	file.		Sub.	file.	viii	iv 00	07	

(52)			(53)			(54)		
						Sub.	File.	
iv	viii	00	34	iv	viii	00	12	
i	3	02	00	i	3	01	36	1
2	2	03	28	2	2	03	02	2
3	1	04	48	3	1	04	32	3
v	vii	06	28	v	vii	05	56	v
i	3	08	03	i	3	07	27	i
2	2	09	40	2	2	09	03	2
3	1	11	23	3	1	10	46	3
vi	1	13	13	vi	1	12	26	vi
i	3	15	10	i	3	14	17	i
2	2	17	18	2	2	16	18	2
3	1	19	30	3	1	18	13	3
vii	v	22	00	vii	v	20	53	vii
i	3	24	44	i	3	23	30	i
2	2	27	53	2	2	26	26	2
3	1	31	01	3	1	29	43	3
viii	iv	35	34	viii	iv	33	33	viii
South Declining			South Declining			South Declining		
55 00			56 00			57 00		
Hours	d.	m.	Hours	d.	m.	Hours	d.	m.
1	3	120	02	1	3	122	26	1
2	2	113	20	2	2	116	02	2
3	1	103	34	3	1	106	32	3
4	ii	93	24	4	ii	96	13	4
5	1	82	55	5	1	85	26	5
6	2	72	47	6	2	74	52	6
7	3	63	30	7	3	65	13	7
8	ii	55	29	8	ii	56	40	8
9	1	48	11	9	1	49	26	9
10	2	42	22	10	2	43	02	10
11	3	37	18	11	3	37	50	11
xii	33	06	xii	33	24	xii	33	42
1	3	29	10	1	3	29	21	1
2	2	25	52	2	2	26	01	2

(55)				(56)				(57)			
3	i	22	57	3	i	23	05	3	i	23	10
i	xi	20	23	i	xi	20	30	i	xi	20	33
1	3	18	04	1	3	18	10	1	3	18	16
2	2	15	56	2	2	16	03	2	2	16	09
3	1	14	00	3	1	14	10	3	1	14	15
ii	x	12	13	ii	x	12	17	ii	x	12	21
4	3	10	30	4	3	10	40	4	3	10	42
5	2	08	53	5	2	09	07	5	2	09	10
6	1	07	22	6	1	07	31	6	1	07	35
iii	ix	05	53	iii	ix	06	00	iii	ix	06	08
7	3	04	30	7	3	04	43	7	3	04	45
8	2	03	07	8	2	03	22	8	2	03	33
9	1	01	45	9	1	02	02	9	1	02	18
iv	viii	00	26	iv	viii	00	41	iv	viii	01	02
Sub.		stile.		Sub.		stile.		Sub.		stile.	
1	3	00	34	1	3	00	34	1	3	00	34
2	0	02	14	2	0	01	53	2	0	01	30
3	0	03	35	3	0	03	12	3	0	02	47
v	vi	04	02	v	vii	04	33	v	vii	04	06
1	0	06	26	1	3	05	55	1	3	05	26
2	0	07	57	2	2	07	22	2	2	06	49
3	1	09	26	3	1	08	50	3	1	08	15
vi	0	11	05	vi	10	24	24	vi	10	09	44
1	3	12	51	1	3	12	09	1	3	11	22
2	2	14	38	2	2	13	50	2	2	13	08
3	1	16	38	3	1	15	45	3	1	14	57
vii	0	18	50	vii	0	17	52	vii	0	16	36
1	3	21	16	1	3	20	10	1	3	19	10
2	2	24	01	2	2	21	43	2	2	21	38
3	1	27	02	3	1	25	37	3	1	24	22
viii	iv	30	30	viii	iv	28	34	viii	iv	27	30

South Declining. 38 00.			South Declining. 59 00.			South Declining. 60 00.		
Hours.	D.	M.	Hours.	D.	M.	Hours.	D.	M.
1	2	122 10	3	1	114 02	3	1	119 19
2	1	113 18	x	ii	104 40	x	2	108 40
x	ii	102 38	1	3	94 07	1	3	96 17
1	3	91 29	2	2	81 26	2	2	84 15
2	2	79 08	3	1	70 20	3	1	82 40
3	1	69 20	xi	1	60 28	xi	1	61 35
xi	1	60 10	1	3	51 57	1	3	51 10
1	3	51 20	2	2	44 56	2	2	45 53
2	2	44 26	3	1	38 52	3	1	39 27
3	1	38 39	xii	1	34 17	xii	1	34 37
xii	3	34 00	1	3	35 54	1	3	30 08
1	2	29 50	2	2	26 30	2	2	26 27
2	2	26 20	3	1	23 20	3	1	23 21
3	1	23 20	1	xi	20 38	1	xi	20 41
1	xi	20 39	1	3	18 17	1	3	18 20
1	3	18 23	2	2	16 10	2	2	16 31
2	2	16 14	3	1	14 33	3	1	14 16
3	1	14 18	xi	1	12 30	xi	1	12 31
xi	1	12 30	1	3	10 52	1	3	10 52
1	3	10 56	2	2	09 20	2	2	09 24
2	2	09 18	3	1	07 55	3	1	07 58
3	1	07 39	iii	ix	06 35	iii	ix	06 39
ix	iii	06 26	1	3	05 15	1	3	05 23
1	3	05 64	2	2	03 52	2	2	04 07
2	2	05 46	3	1	02 45	3	1	02 55
3	1	02 31	iv	viii	01 31	iv	viii	01 43
iv	viii	01 16	1	3	00 19	1	3	00 33
1	3	00 02	Sub.	File.		Sub.	File.	
Sub.	File.		2	2	00 52	2	2	00 34
2	2	01 10	3	1	02 05	3	1	01 25
3	1	02 25	v	vii	03 18	v	vii	02 56
v	vii	03 41	1	3	04 33	1	3	04 03
1	3	04 58	2	2	05 40	2	2	05 23
2	2	06 20	3	1	07 10	3	1	06 40
3	1	07 43	vi	vi	08 35	vi	vi	08 20
vi	vi	09 10	1	3	10 03	1	3	09 26
1	3	10 43	2	2	11 37	2	2	10 57
2	2	12 21	3	1	13 18	3	1	12 36
3	1	14 08	vii	v	15 09	vii	v	14 20
vii	v	16 03	1	3	17 10	1	3	16 15
1	3	18 08	2	2	19 23	2	2	18 22
2	2	20 30	3	1	21 36	3	1	20 45
3	1	23 10	viii	iv	24 46	viii	iv	23 28
viii	iv	26 11						

The SECOND PART.

Arithmetical
And
Instrumental

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LIBRARY

YOU have here the making of all Sorts of *Dials Arithmetically*, by *Artificial Sines*, and *Tangents*: And *Instrumentally* by a Ruler in p. 62 of the first Chapter; I think I need not tell you what the Ruler is, nor what Lines are upon it, for they are known to every one that understands the Letter that stands at the beginning of each Lines; and therefore I shall say no more of this Ruler as to the Description of it.

How to make an Equinoctial Dial.

Fig. 20.

Draw two Parallel Lines, as C, E, D, and A, F, B, and in the middle of the Plane, draw the Perpendicular FE, for the Hour of 12; then take from your Polar Scale (either of them will do) 1, 2, 3, 4, and 5 Hours successively one after another, and place from 12 on the parallel Lines, from E, and F, toward C, and D, and AB, and Lines drawn from one point to the other, are the Hour-lines required.

The Stiles Height is the distance between 12 and 3.

The

The Second PART.

CHAP. I.

Fig. 10.

How to make a Polar Dial.

A Polar-Dial is a Dial that lieth upon the Equinoctial Circle, whose Scile or Axis is 90 deg. high, or (more properly speaking) is Perpendicular to the Plane, and is the easiest to be made of any Dial whatsoever; for the Equinoctial Circle being divided into 360 deg. one 24 part is 15 deg. or one Hour; this Dial being an Horizontal Dial under the Poles of the World, where the Sun is said to move equal Space in equal Time; but the Shadow in all other Places is Irregular.

Therefore the making of this Dial is nothing but dividing a Circle into 24 equal parts, and setting up an Iron-Pin perpendicular to its Plane; your Dial is finished.

And this Plane, or Dial is capable of receiving all the 24 Hours, in the Latitude of 90 deg. Because the Sun keepeth continually moving round it, and round it again for the space of almost half a Year: And in all other Latitudes according to the length of their Days: So in our Latitude are put on all the Hours from 4 in the Morning till 8 at Night.

But the making of this Dial according to Geometrical Rule is laid down in Chap. 7. p. 21.

CHAP.

C H A P. II.

Of Vertical or Horizontal Planes, Arithmetically.

IN these Planes there is nothing required but the *Height of the Pole above the Plane*, which in all Places, is equal to the Latitude of the Place, for which the Dial is made.

First, Therefore prepare a Table, according to the Example adjoyning, wherein set down all the Hours in order from 12, as they are equidistant from the *Meridian*, viz. 11 and 1, 10 and 2, 9 and 3, 8 and 4, unto them adjoyn the Equinoctial Distances, that is, for the first Hour 15 Degrees, for the second Hour 30 deg. for the 3d Hour 45 deg. and so of the rest, by continual addition of 15 deg. then take out of your Canon (or Tables) upon a loose Paper, the Logarithm or Artificial Sign of the Elevation of the Pole above this Plane, which for 51 deg. 30 min. The Height of the Pole here at *London*, is 9,893544, and is always one of the middle Proportionals, in finding out every Hours distance, apply it to 9,428052, the Logar. tangent of 15 deg. (which is the first Hours Equinoctial distance) and add them both together, there shall come forth a new Logar. tangent of 19,321596, for that Hours distance, which set down in the Table by 15 d. in the same place, remove your Paper, to the Logar. tangent of 30 deg. and add them both together, you shall produce a new Logar. Tangent of 19,893544, for the Hour of 2 and 10, which set down in the Table by 30 deg. work after the same manner

manner, with the Logar. Tangent of 45, 60, 75 deg. for the rest of the Hours.

Hours.	Equino- dial di- stances.	The Logar- ithm of the Tangents.	The new Logar. of the Tangents.	The true hour di- stances upon the Plane.
XII.	0	0	0	0
XI	15	9,428052	19,321596	11
X	30	9,761439	19,654982	24
IX	45	10,000000	19,893544	38
VIII	60	10,138561	10,132105	53
VII	75	10,571947	10,465491	71
VI.	93	Infinite.	Infinite.	90

The Height of the Stile 51 deg. 30 min.

The Canon for Calculation is,

As the Sine of 90 deg.

Is to the Sine of the Latitude, 51 deg. 30 min.

So is the Tangent of 15 deg. (the Equinoctial Distance of one Hour of 30 deg. for two Hours; of 45 deg. for three Hours, &c.

To the Tangent of 11 deg. 50 min. for 11 and 1—of 24 deg. 20 min. for 10 and 2—of 38 deg. 3 min. for 9 and 3, &c.

Now if you design to put into this Dial, or any of the rest that follow, the half Hours and Quarters, their Distances upon the Plane are as easily found by the same Rules, as the Hours were, for by adding the Log. Sine of the Height of the Pole, or Stile unto the Log. Tangents of 3 deg.

3 deg. 45 min. 7 deg. 30 min. and 11 deg. 25 min. which are the Equinoctial Distances of Half-Hours and Quarters, there will come forth the Log. Tangents of new Distances, proper to the Halfe and Quarters. *Note*, There is a Table of Equinoctial Distances for Hours, Halfe and Quarters in Page 31.

Note, Thus you have all the Hour-lines; but for the Drawing of it take the Directions of the I Chapter, in Page 15.

CHAP. III.

How to draw the Hour-lines upon a Direct South Dial in the Lat. of 51 deg. 30 min.

IT is almost needless to say any Thing concerning the marking of a Direct South Dial, for there is but little Difference between it and the Horizontal, only you must take Notice that this *Plane* respecteth the South Pole, which Pole is elevated thereon 38 deg. 30 min. (always) the Complement of the Latitude, therefore take 38 deg. 30 min. out of your Scale of Latitudes, and finish your Dial in all Respects as you did the Horizontal: But observe, that whereas in that Dial, the Hours of 1, 2, 3, &c. were set off on your Left-hand of the Meridian, so the same Hours must in this Dial be set off on your Right-Hand of the Meridian; if you well observe what was said in the IXth Chapter, Page 24.

Note, That the Angle which the *Stile* makes with the Meridian, must (as I have said before) be 38 deg. 30 min.

F

2. And

And lastly, That the *Stile* must stand at right Angles with the Plane.

Concerning a Direct North Dial.

A Direct North Dial is the same with the South, only the *Stile* must point upwards toward the North Pole, and the hours about Mid night as 9, 10, 11, 12: 1, 2, and 3 must be left out, and 4 and 5 in the Morning, and 7 and 8 at Night must be drawn thro' the Center, as in the Horizontal Dial: So is your North Dial finished.

SECT. I.

Fig. 17.

How to draw an Horizontal Dial, for the Latitude of 41. 30. by the Scale of Latitude, and the Inclination of the Meridian.

1. DRAW the Line A B, for 6 a Clock Morning and Evening.
2. Draw N S Perpendicular to A B, this Line shall be the Meridian, or 12 a Clock Hour line.
3. Let C, the Intersection of the foresaid Lines be the Center of the Dial, then repair to your Scale of Latitudes, and fixing one Foot of your Compasses at the beginning, extend the other to 41 deg. 30 min. and set that from C to A, and from C to B, then open your Compasses the whole length of the line of Inclination, or the Scale of 90 deg. setting that extent one Foot in A, move the other till it meet with the Meridian line N S as at O, and draw the Line A O, and B O.
4. This done, extend your Compasses from the

be

beginning of your Scale of 90 deg. to 15 deg. and set from O towards A and B, for the Hours of 11 and 1, also from A towards O, for 5 a Clock, and from B towards O, for 7 a Clock. Then extend your Compasses from the beginning of your Scale to 30 deg. and set from O towards A, and B, for the Hours of 2 and 10. Likewise from A towards O, for 4, and from B towards O, for 8 of the Clock. Then take 45 deg. and set from O, toward A, and B, for the Hours of 3, and 9, so you have 12 Points for Hours. Now Lines drawn from the Center C, to each of those Points shall be the Hours required.

Note That the Hours of 4 and 5 in the Morning, and 7 and 8 in the Evening, must be drawn thro' the Center C; and if you design the halfs and quarters of an Hour on your Dial, observe what was said in the last Chapter.

2. With a Line of Chord, make an Angle of 54 deg. for the Spile of your Dial, and set it over the Meridian-line C O at Right Angle, and your Dial is finished.

C H A P. V.

Fig. 21.

How to draw Hour-lines upon a South or North Dial Declining either East or West to any Declination.

BEFORE the Hour-lines can be drawn upon any of those Planes two Things must be given, and three other Things must be found.

The Things given are,

1. The Latitude of the Place.

F 2

2. The

2. The Planes Declination,

The Things that must be found are,

1. The Substiles Distance from the Meridian or 12 a Clock Hour-line.
2. The Height of the Stile above the Plane.
3. The Planes difference of Longitude.

Example, Suppose that in the Latitude of London $51^{\circ} 30'$, it were required to draw a Dial 25° deg. of Declination Westwards.

The Canon for Calculation are,

As the Radius $90:00-10,000,000$

Is to the Sign of the Declination $25:00-9,625,948$

So is the Co-Tang. of the Lat. $51:30-9,900,605$

To the Tan of the Sub. dist. $18:33-19,525,653$

As the Radius $90:00-10,000,000$

Is to the Co-sign of the Decl. $25:00-9,957,276$

So is the Co-sign of the Lat. $51:30-9,794,149$

To the sign of the Stiles height, $34:21-19,751,425$

As the Radius $90:00-10,000,000$

Is to the Co-Tang. of the Dec. $25:00-10,331,327$

So is the Sign of the Latitude $51:30-9,893,544$

To the Co-Tang. of the Planes $30:47-10,225,871$

Long.

Having

Having proceeded, thus far prepare a Table of Hours fit for the Plane, such as is here done.

Then against XII. set the Planes Differences of Longitude 30 deg. 47 min. (in the second Column) and from it subtract 15 deg. and there will remain 15: 47, which set against XI. and I. Then subtract 15 and there will remain only 47 min. which set against II. Then because

		Equinoctial Distances.		True Hours distance from the Subfile	
		D.	M.	D.	M.
III.	IX	75	47	65	49
II.	X	60	47	45	16
I.	XI	45	47	30	07
	XII	30	47	18	33
XI.	I	15	47	09	04
X.	II	00	47	00	02
Subfile		Subfile		Subfile	
IX.	III	14	13	08	08
VIII.	III	29	13	17	31
VII.	V	44	13	28	47
	VI	59	13	43	27
V.	VII	74	13	63	24
IV.	VIII	86	13	88	37

47 min. is less than 15 deg. write the word Subfile under it, and subtract it from 15 deg. there will remain 14 deg 13 min. which set against IX and III. Then to 14 deg. 13 min. add 15 deg. it maketh 29: 13. which set against VIII and IV. Then add 15 deg. it maketh 44: 47 which set against VII and V. Then add 15 and it makes 59: 47 which set against VI. then 15 more makes 74: 47, which set against V and VII, then 15 more makes 89: 47, having finished your Table on this side of 12 a Clock, I begin again at 12 and add 15 it makes 45: 47, which set against I. and XI.

and 15 more makes 60: 47 which set against II and X, and 15 more makes 77: 47, which set against III and IX. And thus you have made a Table fit for Calculation, viz. for finding the true Hour-distances on the Plane.

The Canon for Calculation is, as follows:
 As the Radius, — — — 90000000000000
 Is to the Sin of the Stiles height, 34: 21: 9, 75: 1469
 So is the Tan. of the Equ. dist. 14: 13: 09, 403718
 To the Tangent of, — — — 08208: 19, 159187

Which is the Distance of 9 and 3 of the Clock from the Substile.

And so will the Tangent of the next Equinoctial Distance, 19: 13, be to the Tangent of 17: 11, for the Distance of the Hour-line of 8, and from the Substile, and so for all the rest of the Hours, as in the Table.

Having calculated all your Hours, you have Directions for describing them on the Plane, by Chap. V. Page 19.

S E C T. I.
 How to draw Hour-lines on South or North Declining Planes by your Line of Latitude and Inclination of Meridian on your Ruler in Page 62.

An Example of the foregoing Dial, Dec. 25 deg.

HAVING calculated your Requisites belonging to your Dial, and made a Table of Equi-

Equinoctial Distances, according to the former part of this Chapter, you will find them to be as followeth.

To draw the Dial.

1. Draw an *Horizontal Line* on the *Plane*.

2. Draw C 12, the *Meridian*, or 12 a *Clock Hour-line*, perpendicular to the *Horizontal-line* of your *Plane*, and with a *Line of Chords* make the Angle F C 12, equal to the *Substile* distance from the *Meridian*, and draw CF for the *Substile* on the right-hand of the *Meridian* because the *Plane* *Vealines West*.

3. Draw the Line AB, perpendicular to the *Substile*, and passing thro' the Center at C, then out of your line of *Latitude* take 34 : 21 (the height of your *Stile*) and set it from C to A, and from C to B, then take in your *Compasses* the whole length of your *Scale of Inclination of Meridian*, and let one Foot in A, and turn the other about till it will touch the *Substilar line*, as at F, and draw the Line FA, and FB.

4. Then repair to your *Table*, and take off your *Scale of Inclination of Meridian*, 15 deg. 47 min.

Latitude.	31	30
Th. Decl.	25	00
Sub. Diff.	18	33
Stiles Height.	34	21
Plan. Long.	30	47
Hour.	Equinoct	
	D.	M.
IX.	71	47
X.	60	47
XI.	45	47
XII.	30	47
I.	15	47
II.	00	47
Sub.	stile.	
III.	14	13
IV.	29	13
V.	44	13
VI.	59	13
VII.	74	13
VIII.	89	13

30 : 47, 45 : 47, 60 : 47, 75 : 47, and set from F the Substile towards A, for the Hours of 2, 1, 12, 11, 10, and 9 of the Clock; again take 14 : 13, 29 : 13, 44 : 13, 59 : 13, 74 : 13, and 89 : 13, and set from F, towards B, for the Hours of 3, 4, 5, 6, 7 and 8: *Note*, 8 falling above the *Horizontal-line*, is drawn thro' the Center for 8 in the Morning, as you see in the Figure.

5. Let your Hour-lines be drawn from the Center thro' every mark in the Line FA, and FB, and your Stile set on the Substile, making an Angle of 34 : 21, and your Dial is finished.

S E C T. II.

How by the Height of the Stile, the Declination of the Sun, to find what Time the Sun shall pass, from one side of a Declining Plane to the other.

The Canon for Calculation.

As the Radius, —	90 : 00	— 10,00000
Is to the <i>Tang.</i> of the <i>Sun's Decl.</i>	21 : 30	— 9,63830
So is the <i>Tang.</i> of the <i>Stiles hei.</i>	34 : 21	— <u>9,83469</u>
To this Co-sine, <i>viz.</i>	72 : 43	— <u>19,47299</u>
From which Subtract —	30 : 47	
the <i>Planes Long.</i>	— —	
And there remains,	41 : 56	

Which 41 : 56 resolved into Time (by allowing 15 deg. to one Hour, and the odd deg. 4 min. of Time,) maketh 2 Hours 48 min. Afternoon, that the Sun forsaketh the South Dial Declining

clining East, to shine upon the *North Dial Declining West*: So by the same Calculation the Sun forsaketh the *North Declining East* 2 Hours 48 min. before Noon, to Shine upon the *South Declining West*.

Again the Sun being in vs, the *Southern Sine*
unto — — — — — 72—43

Add the *Planes Longitude* — — — 30—47

————— 102—90

The Sum is, — — — — — 103—30

Whose Complement to 180 deg. is, 76—30

Which converted into Time is 5 Hours 6 min. for the Time in Capricorn, when the Sun passeth from one side of the *Plane* to the other, between which two Limets the Annual Variety of the Sun is concluded.

Lastly, In the making of this Dial you have made Four, viz. First a *South Declining West* 25 deg. but if you turn your Paper and look thro' it, it will on the Back-side be a *South Declining East*, 25 deg. Only the Afternoon Hours on the *West Dial*, must be the Morning Hours on the *East*, and if you turn your Dial the Bottom upwards, and reckon your Hours the contrary way: So a *South East Decliner*, will be a *North East Decliner*, and a *South West Decliner*, will be a *North West Decliner*, leaving out the Hour-lines (which will be needless) before the Sun-setting, and after the Sun-rising.

Note, That the Substile in all *Decliners*, goeth from the *Meridian* towards that Coast, which is contrary to the Coast of the *Planes Declination*.

C H A P. VI.

Fig. 22

How to draw Hour-lines upon a Far Declining Dial, by the two Polar Scales on the Ruler.

Example of a South Dial Declining East 80 deg. in the Latitude of 51 deg. 30 min.

By the Directions of the last Chapter (or by Page 26) you shall find the Inclination of the Meridian to be 82 deg. 9 min. and the Height of the Style above the Plane 6 deg. 12 min. and the Substile's Distance from the Meridian 38 deg. 4 min.

Proceed thus, draw first, the Perpendicular GH, then with the Radius of your Line of Chords, describe the Arch LM, and set off the Substile and Style with the same Line of Chords, according to their respective Angles, and draw the prick'd line CBA for the Substile; and GIK for the Style.

Then choose any point in the Substile, as A, through which Point A, draw a Line at length, Perpendicular to it, as the Line EAC, that done fix one Foot of your Compasses at the beginning of your longest Polar Scale, and extend the other to the Hour of 1, set off this extent from A to E, and through the Point C draw a Line Parallel to the Style GIK, as the Line CD, so shall CD be the Style increased. Then open your Compasses from the beginning of your second or lesser Polar Scale, to 2 Hours, and with that extent, place one Foot of your Compasses in the Substile ABC, carrying

ing it along the said Line, until the other Foot of the Compasses just touch the Line CD, and there make a mark, as at B, through which mark B, draw a Line at length, and Parallel to the Line EAC, as the Line DBF. Then considering the Inclination of the Meridian was found to be 82 deg. 9 min. find it on the first Scale, or Scale of 90 deg. and against it on the first Scale you shall find 5 Hours 29 Minutes, by which it appears that the Substile falleth between the Hours of 6 and 7 in the Morning.

Now according to the Inclination of Meridians 5 Hours 29 Minutes, you may proceed to make a Table, and set off the Hours accordingly, as followeth.

Open your Compasses too 20 Hours 29 min. of the greater Polar Scale, and set it for the Hour of 7, in the Line EAC. Then open the Compasses to 1 Hour 29 min. of the same Scale, and set it from A to 8. Then open your Compasses to 2 Hours 29 min. and set it from A to 9. Then open your Compasses to 3 Hours 29 min. and set it from A to 10. Lastly, Open the Compasses 4 Hours 29 min. and set it from A to 11.

Now having found the Points for the Hours on one side of the Substile from A towards E, you must do the like for the other Hours on the other side of the Substile. And considering that the first Hour from the Substile towards E, namely 6 A 7, contains the Distance of 00 Hours 29 min. as by the following Table; the Complement thereof to 60 min. or an Hour, is 00 Hours 31 min. as the said Table appears.

Table

From A towards E.			From A towards C.		
H.	M.	H. on the Plane.	H.	M.	H. on the Plane.
0	29	A	7	0	31 A
1	29	A	8	1	31 A
2	29	A	9	2	31 A
3	29	A	10	3	31 A
4	29	A	11	4	31 A

Proceed to set off 60 Hours 31 min. taken from the same Polar Scale from A to the Hour of 6, and extend your Compasses from the beginning of the Scale to 1 Hour 31 min. and set it from A to 5, also to 2 Hours 31 min. and set it from A to 4, also to 3 Hours 31 min. and set it from A to 3; and lastly, The extent of the Compasses from the beginning of the Scale to 4 Hours 31 min. set off from A to 2, and so you have Points for all the Hours on the Plane on the Line CAH.

Now for the other Line DBF, you must set off the Hours thereon (taken out of the lesser Polar Scale) from B both ways according to the Table, in all Respects as you did set off the Hours from A. This being done, draw Lines through the respective Points found in the Lines CAH, and DBF, and those Lines shall be the Hour-lines for this Dial.

The Stile must be a thin Plate of Brass or Iron, and stand directly over the Substile, as in the Figure is demonstrated, by AB and CD.

Thus have you finished your Dial, and in the making of this you have made a South Declining West

West 80 deg. Also, for if you turn the Paper, and look through it, it will on the back-side appear *Declining West 80 deg.* only the Forenoon hours in this, must be the Afternoon Hours in that: Nay, in rigour, you have in this one Dial made four, a *North Declining*, either *East* or *West*.

CHAP. VII.

Fig. 182

Now to draw Hour-lines upon a direct East-Dial, Arithmetically.

LET there be an *East-Dial*, whose breadth is 6 Inches; and it is required to put on all the Hour-lines from 6 in the Morning till 11 at Noon; here you have 5 Hours and 6 Inches: Therefore, before you can work the Operation, you must turn the Hours into Degrees, by allowing for every Hour 15 Degrees, so you will have 75 Degrees for 5 Hours; then turn the Inches into Parts, by allowing 100 Parts to every Inch, so you will have 600 Parts.

I. For the Height of the Stile.

As the Radius 90
Is to the Tangent of 5 Hours 75 deg. com. A.
So is the Log. of the distance from 6, 600 parts

To the Log. of the Stiles height, in Parts 161.

That is, 1 Inch, 61 Parts of an Inch, an Inch divided into 100 Parts.

As

Also for it you turn the Paper
 For the Hour-lines distance from VI. And
 As the Radius 90. 10,00000
 Is to the Log. of the Stiles height 161. 2,20683
 So is the Tangent of 15 deg. for 7 a Clock 9,46883
 To the Log. of the first Hour 43 Parts. 1,66988

As the Radius 90. 10,00000
 Is to the Log. of the Stiles height 161. 2,20683
 So is the Tangent of 30 deg. for 8 a Clock, 9,76143
 To the Log. of the 2d Hour 43 Parts. 1,66988

As the Radius 90. 10,00000
 Is to the Log. of the Stiles height 161. 2,20683
 So is the Tang. of 45 deg. for 9 a Clock 10,00000
 To the Log. of the 3d Hour, 161 Parts. 1,66988

As the Radius 90. 10,00000
 Is to the Log. of the Stiles height 161. 2,20683
 So is the Tang. of 60 deg. for 10 a Clock 10,76143
 To the Log. of the 4th Hour, 379 Parts. 1,66988

As the Radius 90. 10,00000
 Is to the Log. of the Stiles height 161. 2,20683
 So is the Tang. of 75 deg. for 11 a Clock 11,66988
 To the Log. of the 5th Hour, 600 Parts. 1,66988

Having thus far proceeded, that 5 Hours from 6 is calculated, namely, 7, 8, 9, 10, there are yet 4 and 5 in the Morning that must be drawn the same distance from 6 in the Morning, as 7 and 8 are: therefore for your better instruction, see the following Dial, and imitate this Geometrical Construction.

First, Square out your Dial and draw the Line D, A, C, towards the bottom of your Plane; then with 60 degrees of Chords in the Point C, on the edge

edge of the Dial, describe a part of a Circle as A. B. and set from A. to B. the Complement of your Latitude $38^{\circ} 20'$ and draw the Line CBF, thro' the Plane for the Equinoctial.

Secondly, Have Recourse to your Table, and take, in your Compasses, the distance in Parts between 6 of the Clock and 11, namely 600, and make Marks with both Feet in the Equinoctial for the Hour-lines of 6 in the Morning, and 11, but remember to leave room above 6, for 4 and 5 in the Morning, then take in your Compasses 43 Parts, and set from 6, to 7, and 5, then take in your Compasses 92 Parts, and set in the Equator or Equinoctial, from 6 to 8 and 4; then take in your Compasses 161, and set in the Equinoctial from 6, to 9. Lastly, Take 279 Parts, and set in the Equinoctial from 6 to 10, and thro' the Points in the Equinoctial draw Perpendiculars, and they shall be the true Hour-lines.

Note, The Sule must be the breadth of 6 and 9 of the Clock, as you see in the Figure, and must stand perpendicularly in the Hour-line of 6 of the Clock.

IV	223	Note, If you have
V	243	a Mind to draw
VI	260	the Quarters and
VII	279	Half Hours, and
VIII	298	Three Quarters,
IX	316	you may, if you
X	379	observe what was
XI	600	said in Ch. 2. P. 65.

How to draw the Hour-lines, upon a Direct East or West Dial instrumentally by the Polar Scale.

1. UPON the Point C, if it be an *East-Dial*, or upon the Point D, if a *West*, with 60 deg. of your Line of Chords, draw an obscure part of a Circle as AB, and in that Arch from A to B, set off the *Height* of the *Equinoctial*, 38 deg. 30 min. and draw the Line CDE, then in some convenient Place of the Line CE, as at R, draw the Line GRF, at right Angles to the Line EDC, so shall GRF, be the Substile and Hour-line of 6.

2. Draw IH, parallel to the Line EDC.

3. Repair to either of your *Scales* known by the Letters [Pol.] and fix one Foot of your Compasses at the beginning of the said *Scale*, and extend the other Foot to the Hour of 1. Set off that extent from G to 5, and from G to 7, and on its parallel EC, from R both ways, and draw the Hours of 5 and 7 parallel to the Substile and Hour-line of 6: Then take in your Compasses the distance from the beginning of the *Scale* to 2 hours, and set it off from G to 4, and from G to 8, and also from R both ways, and draw the hour of 4 and 8 parallel to the other; so you have no more hours to set off towards I, being 4 is the hour of Sun-rising; but proceed to set off the rest of the hours towards H, as you did the other hours, taking in your Compasses the distances from the beginning of the *Scale* to 3, 4, and 5, and setting each distance off respectively from G towards H, at 9, 10, 11, and also

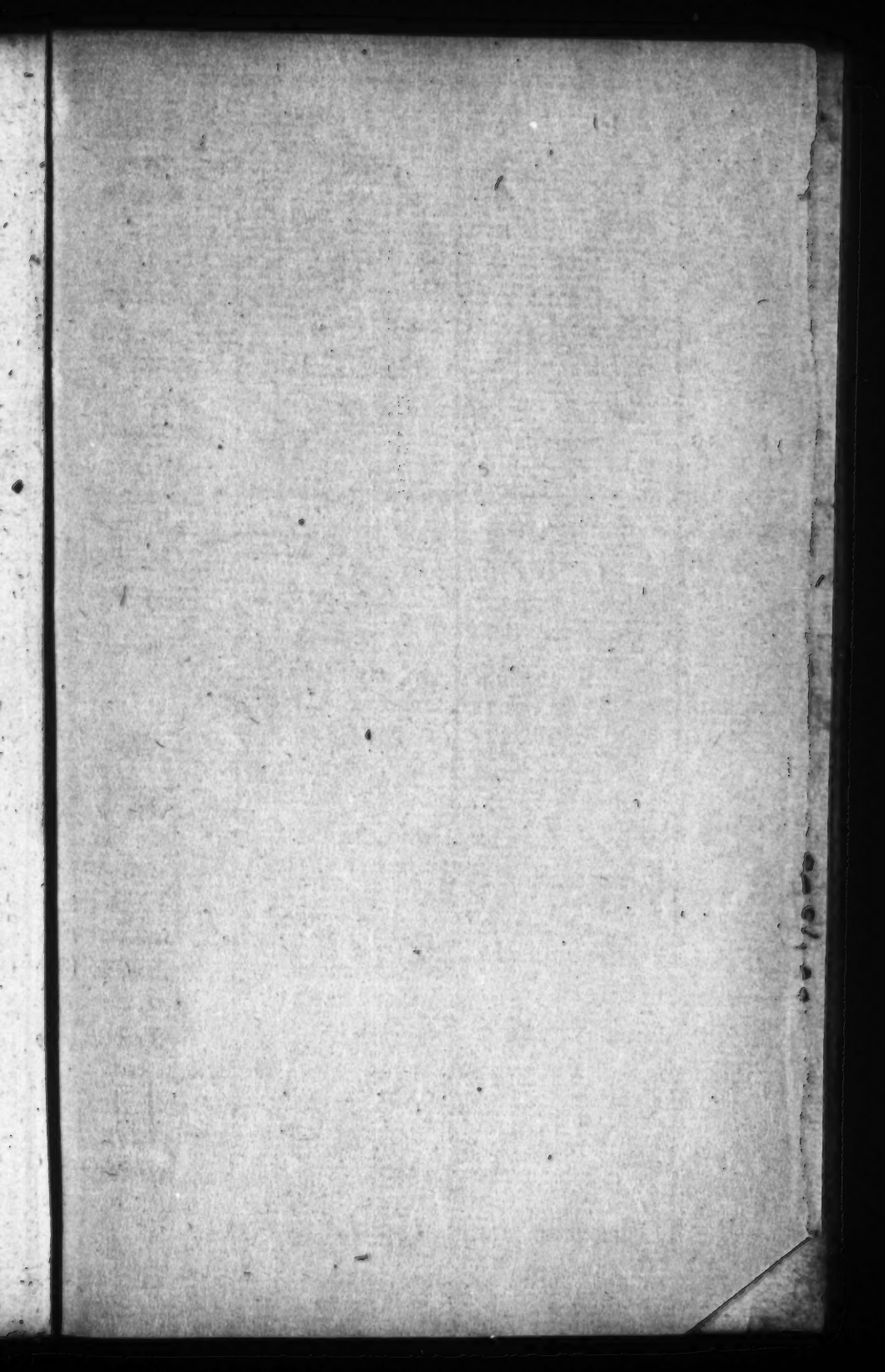


Fig. 13.
The Clocke Board.



Fig. 14.



Fig. 15.



Fig. 16.

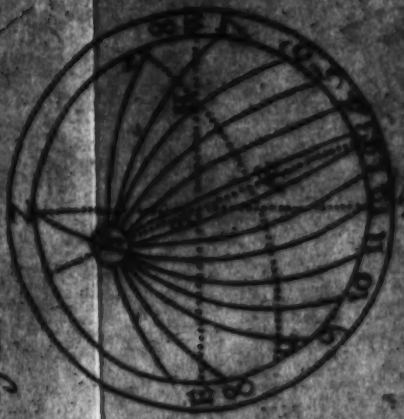


Fig. 17.



Fig. 18.





also from R towards C, and draw the hours of 9, 10, and 11: And so you have all the hours proper for an *East-Dial*.

4. And lastly, The distance from the beginning of the Scale to the hour of 3, gives the height of the Stile, which must stand directly over the *Hour-line* of 6, make Right-Angles therewith, and may be made of a thin Plate of Iron or Brass, or a Pin sharpened, whose Extremity must give the Shadow to the *Hour-lines* on the *Dial*.

Note, That if you turn the *East-Dial* drawn on Paper from you, and look on the back-side, you shall see the perfect Form of a *West-Dial*, only instead of the hours 11, 10, 9, 8, 7, 6, 5, 4, you must write 1, 2, 3, 4, 5, 6, 7 and 8.

C H A P. VIII.

How to find the Reclination of any Plane.

TAKE a *Quadrant* and joyn it to the side of a *Square*, and place the other side of your *Square* to the *Plane*; if the *Plummet* fall Parallel to the side of the *Square*, then the Lower-side of the *Square* stands level, by which draw a *Horizontal-line*, on which erect a *Perpendicular*, and apply your *Square* to that *Perpendicular*, and if the *Plummet* falls parallel to the side of the *Square*, then that is also a *Level-line*, and your *Plane* stands *Horizontally*: If the *Plummet* falls not Parallel to the side of the *Square*, then turn your *Square* until it does, then draw an *Horizontal-line*, on which erect a *Perpendicular* to which apply

apply your Square, and observe what Angle your Plumbet makes on the *Quadrant*, with the side of the Square, that is the Angle of the Reclination of the Plane.

C H A P. IX.

Fig. 19.

Of direct East or West Reclining Dials, and how Hour lines may be described upon them.

AS all Direct North and South Reclining Dials are reduced to New Latitudes, wherein they would be Horizontal Dials; so all Direct East or West Reclining Dials, in any one Latitude, may be reduced to Upright Declining Dials in another Latitude.

Definition. An East or West Reclining Dial, is a Dial that directly beholds the East or West, and Recline or fall back like the Roof of an House.

S E C T. I.

To reduce any East or West Reclining Dial, in any Latitude, to a New Latitude, wherein the Reclining Dial shall become an Upright Dial, and what Declination that Upright Dial shall have in that New Latitude.

Example.

Suppose then, that a direct East, or West Dial in the Latitude of London $51^{\circ} 30'$, should recline from the Zenith 35° deg. in what Latitude will this be an Upright Dial? And what Declination shall it have in that Latitude?

R U L E.

R U L E.

The Complement of the known Latitude, is (always) the New-Latitude; and the Complement of the Reclination is (always) the Declination in that New-Latitude.

So that if an *East* or *West* Dial should recline 35 deg. in the Latitude of 51:30, that will be an Upright Dial, Declining 55 deg. in the Latitude of 38:30.

For 38:30. being the Complement of 51:30, is the New-Latitude. And 55 deg. being the Complement of 38:30 deg. the Dials Reclination is the Declination in that New-Declination.

The Canons for Calculation are.

As the Radius 90:00 — 10,00000
Is to the Sign of the Decl. 55:00 — 9,91336
So is the Co-Tang. of the Lat. 38:30 — 10,09939
To the Tan. of the Sub. dist. 45:52 — 10,01275

As the Radius 90:00 — 10,00000
Is to the Co-sin of the Decl. 55:00 — 9,75859
So is the Co-sin of the Lat. 38:30 — 9,89344
To the sin of the Stiles height, 26:41 — 19,65213



III.

As the Radius. 90:00—10,00000
 Is to the Co-Tang. of the Decli. 55:00— 9,84522
 So is the Sign of the Latitude. 38:30— 9,79415
 To the Co-Tan. of the Plane } 66:27—19,63937
 Long.

West	East	Equinoctial Distances.	True Hours on the Plane.
H.	M.D.	M.D.	M.
10	02 83	33 75	50
09	03 68	33 48	49
08	04 53	33 31	18
07	05 38	33 19	41
06	06 23	33 11	04
05	07 08	33 03	52
Substile.			
04	08 06	27 02	54
03	09 21	27 10	00
02	10 36	27 18	21
01	11 51	27 29	24
12	12 66	27 45	52
11	01 81	27 71	29

Having

Having calculated the *Requisite*, and made the Table after the manner of a declining Dial; and the Hour Arches calculated, we proceed to the Geometrical Projection of a West Recliner.

Draw the Line A, D, for the Horizontal-line of your reclining Plane; then at a convenient distance, and Parallel to the Line A, D, draw the Line G, O, 12, for the 12 a Clock Hour-line, and making G, the Center of your Dial, with 60 deg. of Chords, in G, describe the Circle O, R, p, d, and from O, to R, set the Substiles distance from the *Meridian* 45, 52 min. and from R to p, set 26, 41 the Stiles height, and draw R, G, for the Substile, and p, G, for the Stile; then take out of your Table 03:52, 11:04, 19:41, 31:18, 48:49, 75:50, and set from R, the Substile, for the hours of 5, 6, 7, 8, 9, and 10; likewise take 02:54, 10:00, 18:21, 29:24, 45:52, 71:29, and set for the hours of 4, 3, 2, 1, 12, 11, and thus you have all the hours as you see in Fig. 19.

S E C T. II.

How to draw this Dial by the Line of Latitude and Scale of Inclination of the Meridian.

HAVING found the Equinoctial Distance as before, and drawn the Horizontal-line, the Hour-line of 12, and set off the Substiles distance and Stiles height, proceed after this manner: Draw a Line perpendicular to the Substile, passing thro' the Center, as at G, and take off your line of Latitude 26 deg. 41 min. and set from G to a, and B; then take the length of the whole Scale

G 3

of

of the Inclination of the *Meridian* in your Com-
passes, and set one Foot in *a*, and turn the other
about till it touch, or cross the Subline as at *b*,
and draw the Line *b, a*, and *b, b*, then repair to
your Table of Equinoctial Distances, and take off
your Scale of Inclination of *Meridian* 06:27,
21:27, 36:27, 51:27, 66:27, 81:27, and set one
after another on the Line *b, a*, from *b* towards *a*,
for the hours of 4, 3, 2, 1, 12, and 11 of the
Clock, then take 08:33, 23:33, 38:33, 53:33,
68:33, 83:33, and place from *a* towards *b*, for
the hours of 5, 6, 7, 8, and 9, of the Clock.

Note, That 9 of the Clock is to be drawn thro'
the Center for the hour of 10 in the Morning,
because the Sun shineth not in our Latitude but
12 min. after 8 at Night.

And thus you have at one Work made 4 Dials,
viz. a *West Recliner* and an *East Recliner*, and a
West Incliner and an *East Incliner*, for if you turn
the Dial the bottom upwards, the Center will be
Northwards, and the *Axis* point Southwards, and
those Hours, *viz.* 3, 4, 5, 6, 7 and 8, will be
the Afternoon hours of a *West Inclining Dial*; and
if you observe the same of the *East Reclining*
Dial, it will produce the *East Inclining Dial*.

Note, In the making of the *East Reclining*
Dial, your Center must be on the Left-hand side
of the Plane, and the hours run the other way,
as you may see if you turn your Dial, and look
on the back side of it.

S E C T. II.

The Height of the Stile, the Declination of the Sun, and the Reclination of the Plane given, to find what Time the Sun forsaketh the East or West Reclining Dial, and shineth on the opposite Incliner.

Definition.

THE Planes of East and West Recliners or Incliners lie in the Circle of Position, denominating their Inclination; and to find the Time the Sun forsaketh the one to shine upon the other, observe this general Canon,

As the Radius	90.	19,00000
Is to the Tang. of the Sun's Decl.	23:30	9,69839
So is the Tang. of the Stiles height	36:41	9,70120
To the Co-sine of	77:22	19,31960
To which add the Planes Long.	66:27	<u>143:49</u>
And the Sum is		143:49
Whose Complement to 180 is	36:11	

Which 36:11 resolveth into Time, by allowing 15 deg. to an hour, and to every odd deg. 4 min. giveth 2 hours 24 min. after Noon when the Sun (in Cancer) forsaketh the East Reclining Dial 35, and illuminateth the Opposite, the West Inclining Dial, or It giveth 2 hours 24 min. before Noon, when the Sun parteth from the East Reclining Dial, and shineth upon the West Inclining Dial.

G 4 Note,

Note, That upon all East and West Recliners in the Northern Hemisphere, the North-Pole is elevated; and on their opposite Incliners the South-Pole.

Note, The Meridian upon all East and West Reclining Dials, lies parallel to the Horizon.

CHAP. X.

How to draw the Hour-lines upon Direct South or North Reclining Dials.

SUCH Planes as do directly behold the { North } Point of the Horizon, but to { South } Reclining (or fall backward) from the Zenith towards the { South } are called { North } Direct Planes Reclining: So many Degrees as the Reclination is: And of such Planes there are six Varieties; Three of South; and Three of North Recliners: All which may be reduced to New Latitudes, wherein they will become Horizontal Planes: And consequently Dials (or Hour-lines) may be described upon them by the Precepts delivered in Chap. I. page 15.

1. Of South Recliners.

Examples of all these Varieties of Reclining Planes, in the Latitude of London 51 deg. 30 min. to find the New-Latitude.

1. Variety. Let there be a Direct South Plane in

In the *Latitude* of *London*, which reclines from the *Zenith* thereof 20 deg. In what Latitude will that be an *Horizontal Plane*? The Planes *Reclination* 20 deg. being less then 38 deg. 30 min. the Complement of the Latitude of *London*, Subtract 20 deg. from 38 deg. 30 min. the Remainder (or difference) 18 deg. 30 min. is the New-Longitude. So that an *Horizontal Dial* made for that Latitude shall be a *South-Reclining* 20 deg. in the Latitude of *London*.

2. Variety. If a *South Plane* in the Latitude of 51 deg. 30 min. should recline 60 deg. from the *Zenith* thereof; In what Latitude will that be an *Horizontal Plane*?

The *Reclination* of the Plane 60 deg. being greater then 38 deg. 30 min. the Complement of the Latitude of *London*, Subtract 38 deg. 30 min. from 60 deg. and the Remainder 21 deg. 30 min. is the New-Latitude: And an *Horizontal-Dial* made for that Latitude of 21 deg. 30 min. shall serve for a *South Dial Reclining* 60 deg. in the Latitude of *London*.

3. Variety. If a *South-Plane* in the Latitude of *London* should recline from the *Zenith* thereof 38 deg. 30 min. Equal to the Complement of the Latitude of *London*. Then,

The difference between the Complement of the Latitude of *London* and the *Reclination* being nothing; it shews the New-Latitude to be no Latitude, that is neither Pole hath any Elevation over such a Plane, but is an *Equinoctial Plane*, and must be made by the Rules delivered in the 6th Chapter of this Book, or by Page 61.

mon. which reclines from the Zenith of London, 38 deg. 30 min. should recline from the Zenith 20 deg. In what Latitude will that be an Horizontal Plane?

1. Variety. If a North Plane in the Latitude of 51 deg. 30 min. should recline from the Zenith 20 deg. In what Latitude will that be an Horizontal Plane?

The Reclination 20 deg. being less then the Complement of the Latitude of London, 38 deg. 30 min. add the Reclination 20 deg. and the Complement 38 deg. 30 min. together; their Sum 58 deg. 30 min. is the New Latitude. And an Horizontal-Dial for that shall be a North-Plane Reclining 20 deg. in the Latitude of 51 deg. 30 min.

2. Variety. If a North Plane in the Latitude of London, 51 deg. 30 min. should recline from the Zenith 75 deg. In what Latitude will such a Plane be Horizontal?

The Reclination 75 deg. being greater than 38 deg. 30 min. Add them together and they make 113 deg. 30 min. which being above 90 deg. take the Complement thereof to 180 deg. which is 66 deg. 30 min. And that is the New Latitude. So that an Horizontal-Dial made for the Latitude of 66 deg. 30 min. will be a North-Plane Reclining 75 deg. in the Latitude of London 51 deg. 30 min.

3. Variety. If a North Plane in the Latitude of London 51 deg. 30 min. should recline from the Zenith thereof 51 deg. 30 min. In what Latitude will such a Plane be Horizontal?

Here the Reclination 51 deg. 30 min. is equal to the Latitude of London; and the Sum of the

Re-

Reclination 51° deg. 30 min. and the Complement of the Latitude 38° deg. 30 min. Add together, their Sum is 90° deg. for the New Latitude: And an Horizontal Dial made for that Latitude of 90° deg. will be a *North Plane Reclining* 51° deg. 30 min. of the Latitude of *London*, and must be made by the Rules delivered in the 10th Chapter of this Book.

Note, That upon all *South Reclining Direct Dials*, if the *Reclination* be less than the Complement of the Latitude, the *South-Pole* is elevated; if equal to the Complement of the Latitude, neither Pole is elevated, but is an *Equinoctial*, and is made by Chap. VI. And if more than the Complement of the Latitude, the *North-Pole* is Elevated, and the Center of the Dial is at the bottom. And upon the *North Inclining* less than an *Equinoctial*, the *North-Pole*, equal to an *Equinoctial*, neither Pole, and more than a *Equinoctial* the *South-Pole*.

Note, 2. That upon all *North Direct Reclining Dials*, the *North-Pole*; and on all *Direct Inclining Dials*, the *South-Pole*.

S E C T. I.

The Height of the Stile, the Declination of the Sun, and the Reclination of the Plane given, to find what Time the Sun shall forsake a *North Inclining Plane*, to shine upon a *South Reclining Plane*, opposite thereto.

There is six Varieties of *North and South Reclining and Inclining Dials* — And first of the

the three *South*, I. In that which reclines 20 deg. being less than an Equinoctial, there are given the height of the *Stile* 18 deg. 20 min. the Declination of the Sun 23 : 30, to find at what Time the Sun forsaketh the *North* Inclining Plane, to shine upon the aforesaid *South* Reclining 20 deg.

As the Radius, ————— 90 00 10,00000
Is to the *Tan.* of the Sun's Decl. 23 30 9,63830
So is the *Tan.* of the *Stiles* heig. 18 30 9,52451

To this Co-sine, ————— 81 38 19,16281

Subtract this 81 : 38, out of 90 deg. there will remain 8 deg. 22 min. which converted into Time, giveth 24 min. before 6 in the Morning, and after it at Night, when the Sun in Cancer departeth from the Inclining side of the Plane, and shineth on the Reclining and contrary.

2. Of that which reclines to the Pole, or equal to the Complement of the Latitude; this Dial lyeth in the six a Clock Hour-Circle, and therefore the Case is plain, that the Sun always passes from one side the Flat to the other just at Six of the Clock; and from the 13th of September, to the 20th of March (or the Sun's abode in the *Southern* Signs) the Sun shines not at all upon the reclining side.

3. In that which Reclines 60 deg. being more than an Equinoctial; there are given the *Stiles* height 21 : 30, the Sun's Declination 23 : 30, to find at what Time the Sun parteth with the *North* In-

Inclining Dial, to shine on the South Reclining
opposite thereto,

As the Radius,	90 00	10,00000
Is to the Tan. of the Sun's Dec.	23 30	9,63830
So is the Tan. of the Stiles heig.	21 30	9,59539
To this Co sine,	80 08	19,23369

Subtract this 80 : 08, out of 90, and their will remain 09 : 52, which converted into Time giveth 00 hours 39 min. before Six a Clock in the Morning, and after six at Night, when the Sun in Cancer departs from the Inclining side to illuminate the opposite Recliner, and contrary. And thus may you be satisfied for any other Declination of the Sun whatsoever.

S E C T. II.

The Height of the Stile, the Declination of the Sun, and Reclination of the Plane being given, to find what Time the Sun forsaketh the North Reclining Dial, to shine upon the South Inclining Dial.

IN North Direct Recliners, there are three Varieties which shall be spoke of as followeth.

1. Of the North Reclining 20 deg. This Dial during the Sun's Southern Declination, it only shines upon the Inclining side: But during his abode in the Northern Sines, some part of the Day,

Day on the Reclining side, and some part on the Inclining side; whose Quantity of time is found by the following Proportion.

As the Radius	—	—	90.00.	10.00000
Is to the Tang. of the Sun's decl.	23.30.	9.63830		
So is the Tang. of the stile height,	58.30.	10.21268		
To this Co-sine of	—	—	44.48.	19.95098

Which 44.48, resolved into time, giveth 2 hours 39 min. before, and after Noon, when the Sun in Center forsaketh, and returneth again to the reclining part of the Plane.

2. Of the North Reclining 51.30. being a Polar Dial: This Dial lying in the Equinoctial Circle, hath the Sun during his abode in the Northern Sines, shining only on the reclining Side; and the Sun in the Southern Sines shines upon the Inclining Dial.

3. Of the North Reclining 75 deg. being more than a Polar: This Dial, during the Sun's abode in the Northern Sines, hath the Sun only shining on the Reclining Dial; the rest of the Year it shineth upon both (whose time is easily found by the Declination) until the Meridional reflex of the Sun from the Zenith (or the Zenith distance which is all one) be greater than the Reclination of the Plane, and then it shineth only upon the Inclining Plane.

To find the time of the Year for that, Subtract the Reclination of the Equinoctial 51.30. from the Reclination of the Plane 75, and there will remain

remain 23.30. the Declination of the Parallel in which the Plane lieth, which is the first degree of *Capricorn*, (as you will find by Calculation) for at that time which is the 10th of *December*, the Sun forsaketh the Reclining Plane to shine only on the Inclining Dial, as you will find by the following Proportion.

As the Sine of the Sun's Decl. 23.30. 9. 60069

Is to the Radius ——— 90.00. 10.00000

So is the Sine of the Difference 23.30. 9. 60069

To this Sine ——— 90.00. 10.00000

Which is the third Sign from *Libra*, namely *Capricorn*, (as I said before) when it forsaketh the reclining Dial, to shine only upon the Inclining Dial, and so continues till it ascends again to *Cancer*, which is the Paralellisme with it, which is the 10th of *June*.

I have chose this Dial, reclining 75 deg. because the Operation, or Working, may seem difficult, because the first term 23.30. which must always be subtracted from the third, (which is 23.30,) the remainder is 90.00.

I shall here give you the Working of the Canon for a Dial reclining but 70 deg.

Example.

As the sine of the Sun's Decl. 23.30. 9. 60069

Is to the Radius — — — 90.00. 10.00000

So is the sine of the Difference, 18.28. 9. 50072

To this sine 52.33. 9. 89973

Out

Out of 52. 33, Subtract 30 deg. for the sine of *Libra*, there will remain 22. 33, of *Scorpio* for the place of the Sun, when it forsakerh the reclining Dial, to shine only on the Inclining Dial, till it ascend again into 07. 27, of *Aquarius*, which is in Parallelisme with it, by this place of the Sun every Almanack will shew the time of the Year.

Also, That in making of any of these North or South, reclining Dials, you have made also a Direct North or South Dial inclining from the Zenith towards the Horizon, so many Degrees

as the { Recli- } nation.
 { Incl- }

So that when you have made a South Dial reclining from the Zenith 60 deg. (as is the second Variety of South recliners in this Chapter) you have also a North Dial Inclining to the Horizon 60 deg. either by drawing the Hour-lines and Style through the Center, or by turning the Reclining Dial about upon the Hour-line of VI. And then at the North Pole is Elevated upon the South recliner; so much will the South Pole be Elevated above the North Incliner, &c.





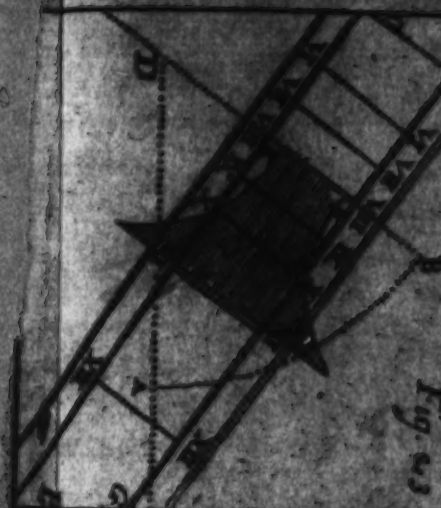
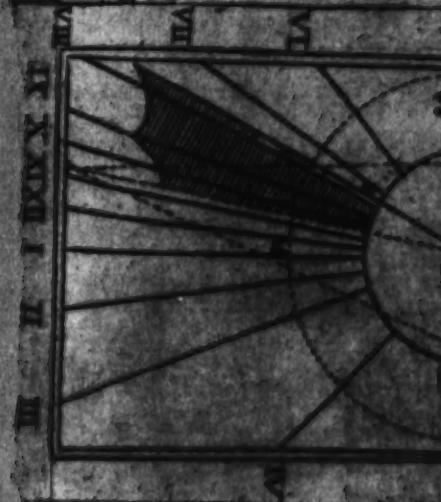
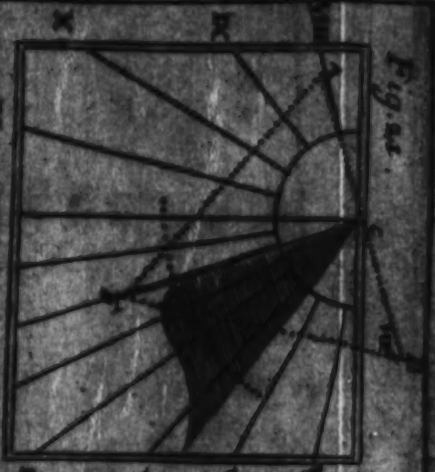
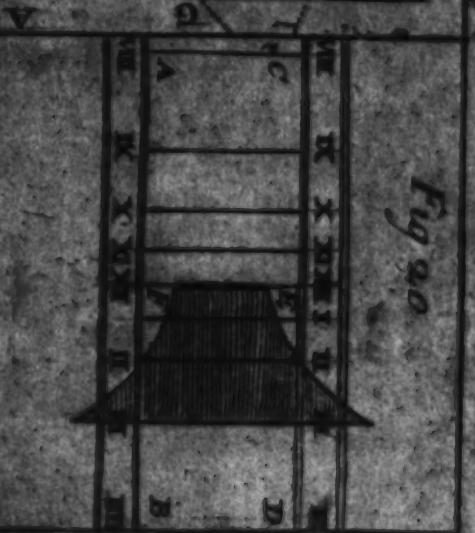


Fig. 43





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Of Declining and Reclining



PLANE CHAPTER

AS there were six Varieties of Direct North and South reclining Planes, so also are their of South and North Declining reclining Planes, viz. Three Varieties of South recliners declining, and as many of North recliners declining.

Of South Recliners Declining Planes.

I. The Declination may be such, that the reclining Plane, shall intersect the Meridian between the Zenith of the Place, and the Pole of the World.

II. The Declination may be such, that the South reclining Plane, may fall upon the Meridian just upon the Pole-point; and such Reclining Declining Planes, are called Equinoctial Decliners.

III. The Declination may be such, that the South Decliner may fall between the Pole of the World, and the Horizon.

These are the three Varieties of South recliners Declining.

In North Decliners reclining, there are three other Varieties.

I. The Declination may be such, that the reclining Plane, may cut the Meridian, between

II. The Declination may be such, that the *North* reclining declining Plane, may cross the *Meridian* in the Point where the Equinoctial cut it.— And such Planes are called Polar declining Planes, because the Poles of them lie in the Axis of the World, and the Substile in such Planes, will be always Perpendicular to the *Meridian* of the Place.

III. The Declination may cause the reclining Plane to cut the *Meridian*, between the Equinoctial and the Horizon.

Examples of all these Varieties follow.

I. Of South Recliners.

The First Variety.

C H A P. XII. Fig. 24.

To draw Hour-lines, upon a South Reclining Plane Declining East or West, which passeth between the Zenith and the Pole.

Example.

L ET the Lat. of the Place be <i>North</i> ,	51 30
The Decl. of the Plane be <i>East</i> ,	20 00
The reclinacion of the Plane be	20 00

I. To find the New-Latitude, wherein this Plane stands as an upright Decliner.

The

The Canon for Calculation,

As the Radius 90 00 10,00000
Is to the Co-sine of the old Decl. 20 00 9,97298
So is the Co-Tang. of the Recl. 20 00 10,43893
To the Tangent of 68 49 10,41191
The Lat. of the place Subtracted 51 30
There remains 17 19

Whose Complement 72 41, is the New-Latitude.

H. The referring of this Plane to a new-Latitude, doth alter the Declination also; therefore a New-Declination must be found.

The Canon for Calculation,

As the Radius 90 00 10,00000
Is to the Co-sine of the Recl. 20 00 9,97298
So is the sine of the old Decl. 20 00 9,83405
To the sine of the new Decl. 18 45 19,60703

Having found the New Latitude and Declination, you may find the Subfiles distance, the Stiles height, and the Planes difference of Longitude, by the Chapter, which are as followeth.

The height of the Pole above the Horiz. 51 30
The Planes old Declination, 20 00
The Reclination 20 00
The Planes New Latitude 72 41
The Planes New Declination 18 45
The Subfiles distance from the Meridian, 05 43
The Stiles height. 16 23
The Planes difference of Longitude, 19 34

Having found the Longitude and rest of the things necessary, you may frame a Table of Angles at the Pole, as was directed in the Chapter, in upright decliners; and from thence you may find also the Hour Arches, and set them down in a Table as you see here followeth.

		Angles at the Pole	Hour Arches		
H. East.	d.	m. d.	m.	H. East.	d.
5	85	26	74	11	7
6	70	26	38	26	6
7	55	26	22	16	5
8	40	26	13	31	4
9	25	26	07	38	3
10	10	26	02	58	2
Subfile				Subfile	
11	04	34	01	17	1
12	19	34	05	44	12
1	34	34	11	00	11
2	49	34	19	07	10
3	64	34	31	40	9
4	79	34	56	53	8

But to draw this Dial upon the Plane in the old Latitude, you are not to place the Hour-line of 12 perpendicular to the Horizon, as in upright plane, but it must make an angle with the Horizontal line of the reclining plane. And therefore the quantity of that Angle must be found therefore,

The Canon for Calculation is,

As the Radius. 90 00 1000000

Is to the sine of the Reclination. 20 00 953485

So is the Tang. of the old Decl. 20 00 956106

To the Co-Tan. of the dif. of the M. & H. 82 54 909511

Having found the Quantity, the *Meridian* makes with the Horizontal-line; the next thing is to find to what Coast it must run, and either above it or below it.

Now in all South Planes that doth recline and decline so much that the Plane becomes less than an *Equinoctial* Plane, the *Meridian* doth descend below the Horizontal line at that end which lies contrary to the Coast of the Declination. And in all North Planes Inclining and Declining, so much as to make it less than an *Equinoctial* Plane, the *Meridian* will ascend above the Horizontal line at that end which lies contrary to the Coast of the Planes Declination.

Having shewed you to what Coast the *Meridian* must run; we now come to the drawing of the Dial, Geometrically.

The Geometrically Projection.

Draw the line W C E, for the Horizontal line of the Plane, then in the point C, with 60. deg. of Chords describe the Circle W M E, and from W, to M, (because the Plane Declines East) set 82. 54, the distance of the *Meridian* and *Horizon*, and draw the line C M, for the Hour-line of 12.

Then take 05. 43. the *Substiles* distance, and set from M, to O, and 16. 23, and set from O

to P, and draw C O, for the *Subfile*, and C P, for the *Stile*.

Lastly, Take 01. 17, 05. 44, 11. 00, 19. 07, 30. 40, and 56. 53, and set from O towards E, Likewise take 02. 58, 07. 38, 13. 31, 23. 16, 38. 26, and 74. 11, and set from O, towards W, and from C, the Center draw lines to every one of the Points, they will be belonging to the Plane.

How to draw this Dial by the Line of Latitudes, and Hour Scale; the Requisites being Calculated.

Having drawn your Horizontal, and set off the distance of the *Meridian* from the *Horizon*, the *Subfiles* distance from the Hour line of 12 or *Meridian*, and the *Stiles* height, draw a Line as B D, passing thro, the Center C, and *Perpendicular* to the *Subfile*.

Then out of your Scale of *Latitudes*, in page 62 take 16, 23, and set from C to B, and D, then take in your *Compasses*, the length of the whole Scale of 6 *Hours*, and set one foot in B, and turn the other foot till it touch the *Subfile*, as at A, and draw a line A B, and A D.

The *Inclination* of *Meridians* in this Example, was found to be 19. 34, seek that on the second Scale of 90 deg. and just against it on the first Scale you shall find 1 hour 19 min. which shews that the *Subfile* stands upon 19 min. past 1, on the *Dial* declining *West*, and 41 min. past 10 on the *Dial* declining *East*.

Now repair to your Table of *Angles* at the *Pole*, and take 04. 34, from your Scale of *Inclination* of *Meridians*,

Mer. and set from A, to XI, and from B, to V, then take 19. 34, and set from A, to XII, and from B, to VI. then take 34. 34, and set from A to I, and from B, to VII. then take 49 34 and set from A, to II, and from B, to VIII. then take 64 34, and set from A, to III. and from B, to IX. then take 79. 34, and set from A, to IV, and from B, to X. *Lastly,* Lines drawn from the Center C, thro' every one of these points shall be the *Hour-lines* for such a *Dial*.

<i>East.</i>	<i>A. P.</i>	<i>West.</i>
II	04 34	I
12	19 34	12
I	34 34	11
2	49 34	10
3	64 34	9
4	79 34	8

How to find what time the Sun forsaketh the North Inclining Plane to shine upon this South reclining Plane.— The Sun being in Cancer.

As the Radius	90 00	10,00000
Is to the Co-Tan. of the Suns Decl.	66 30	9,68865
So is the Tang. of the Stiles height.	15 45	9,45029
To the Co-sine, of	82 57	9,08894
From which Subt. Planes Long.	19 34	
There will remain	63 23	

which converted into time, by allowing 15 deg. for every Hour, and a deg. to 4 min. gives 4 Hours 13 min. after Noon, when the Sun parteth from the Plane, declining and reclining 20 deg. 00 min. *Eastwards,* and shineth upon the *North Inclining West,*

H 4 the

the part opposite thereto : To find the time in the Morning, when the *Sun* forsaketh the *North* Inclining *West*, to shine upon the *South* declining *East*.

Unto the Co-sine before found viz.	82,57
Add the planes Longitude,	19,34
The Sum is,	101 : 91

Which is 102. 31, that be resolved into time giveth 6 hours 50 min. from Noon, that the *Sun* leaveth the *North* Inclining Plane, to shine on the *South* Recliner : Or if you take the Complement of 102. 31, to 180 deg. which is 77. 29, it giveth 5 hours 10 min. the time from Noon.

C H A P. XIII.

HAVING the Declination given, to know what Reclination will make it an *Equinoctial* Dial, Or having the Reclination given, to know what Declination it requires to make it also an *Equinoctial* declining *Dial*.

Whereby you may know at any time if your reclination and declination : or declination and reclination makes your Dial plane more, or less, than an *Equinoctial* declining *Dial*.

Let

Let the Declination given be 65 deg. 40 min.

As the Radius	90 00	10,00000
Is to the Co-Tang. of the Lat.	51 30	9,90060
So is the Co-sine of the Decl.	65 40	9,61494
To the Tang. of the Reclination	18 09	19,51554

Let the Reclination given be as found 18 09.

As the Radius	90 00	10,00000
Is to the Tang. of the Latitude	51 30	10,39939
So is the Tang. of the Reclinar.	18 09	9,51563
To the Co-sine of the Declina.	65 40	19,61502

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#### C H A P. XIV.

Fig. 27.

*How to draw the Hour-lines upon any Declining Equinoctial Plane.*

*Let the Example be of a South Plane, Declining East 65 deg. 40 min. and Reclining 18 deg. 9 min. in the Latitude of London 51 deg. 30 min.*

**I**N Declining Reclining Equinoctial Dials, before the Hour-lines can be drawn, Three Things must be given, and two Things found; the Things given are,

1. The Latitude of the Place, 51 30
2. The Declination of the Plane, 65 40
3. The Planes Reclination, 18 9

*The*

*The Things found are,*

1. The Distance of the *Meridian* and *Horizon*.
2. The Inclination of the *Meridians*.

For the Distance of the *Horizon* and *Meridian*, Thus,

As the Radius, or sine of 90 deg. 10,000000  
 Is to the sine of the Reclination, 18 9—9,493466  
 So is the *Tang.* of the Declinat. 65 40 10,344652  
 To the *Tangent* of 34 deg. 34 min. — 19,838118

Whose Complement 55 deg. 26 min. is the Distance of the *Meridian* and *Substile* from the *Horizontal*-line.

For the Inclination of the *Meridian* of the Place from the *Meridian* of the Plane, Thus,

As the Radius, or sine of 90 deg. 10,000000  
 Is to the sine of the Latitude 51 30—9,893544  
 So is the *Tang.* of the Declina. 65 40 10,344652  
 To the *Tang.* 59 deg. 55 min. ——— 10,237196

Now because 59 deg. 55 min. is almost 4 hours distance from the *Meridian*, I conclude that the *Substile* shall fall near 8 of the Clock, on the *West* side of the *Meridian*: Because the Plane declineth *East*.

The Requisites being found, Draw the *Horizontal*-line DA, then with the Radius of your Line of Chords, describe the Arch AB, and set thereon from

from A to B 55 deg. 26 min. the distance of the Meridian or Substile from the Horizon, and draw B D for the Substile. Then perpendicular to the Substile, draw the Lines F'G and C'E, having found the Inclination of Meridians to be 59 deg. 55 min. find it on the *second Scale*, and against it on the *first Scale* you shall find 3 Hours 59 min.

Then having Recourse to the Table following, set off the Hours from K to H, according to the Directions of the 27th Chapter, for the far decliner, taking the several Distances with your Com-

| From K towards E. |    |                  | From K towards C. |    |                  |
|-------------------|----|------------------|-------------------|----|------------------|
| H.                | M. | H. on the Plane. | H.                | M. | H. on the Plane. |
| 0                 | 59 | K                | 9                 | 0  | 1 K              |
| 1                 | 59 | K                | 10                | 1  | 1 K              |
| 2                 | 59 | K                | 11                | 2  | 1 K              |
| 3                 | 59 | K                | 12                | 3  | 1 K              |
| 4                 | 59 | K                | 1                 | 4  | 1 K              |

passes out of either of the Polar Scales, and setting them off from K towards C and E, as the Table plainly sheweth, drawing Lines parallel to the Substile through those Points, and those lines shall be the Hour-lines required for that Plane.

The extent of the Compasses from the beginning of the same Polar Scale to the Hour of 3, gives the height of the Stile above the Substile, which may be a Plate of Iron or Brass set up just over the Substile H K; and so the Dial is finished.



## S E C T. I.

*How to find what Time the Sun passeth from one side of an Equinoctial Plane to the other.*

**E**VERY Plane Reclining to the Equinoctial is concident, with some Hour-Circle, or part and therefore the Sun, in what parallel passeth from one side of that Plane to the other, at the same Hour and Min. which you may see by the following Canon.

|                                      |       |          |
|--------------------------------------|-------|----------|
| As the sine of the Latitude          | 51 30 | 9,89354  |
| Is to the Radius                     | 90 00 | 10,00000 |
| So is the Co-Tan. of the Plan. decl. | 65 40 | 9,65534  |
| To the Tangent of                    | 30 00 | 9,76180  |

Which 30:00 being converted into Time, giveth 2 Hours from Midnight, when the Sun passeth from the Inclining to the Reclining Plane, and reckoned from Noon, when the Sun forsaketh the reclining Plane, and shineth upon the Inclining side again. And thus it continues till the Northern Amplitude or the Sun is equal to 65:40 the Declination of the Plane, from thenceforth it shines no more upon the Inclining Part in the Morning, and when the Southern Amplitude of the Sun is equal to 65:49, the Declination of the Plane, then it forsaketh the inclining side at Evening also, and the rest of the Year it only Inlightneth the reclining side of the Plane.

*Note,* The Meridian in all these Planes run North and South.

00000.01 00 C H A P. XV. *Fig. 32.*

*How to draw Hour-lines upon a South Reclining Dial, declining East or West, which passeth between the Pole and the Horizon.*

**T**HE third Variety in South declining reclining Dials, is of those that pass between the Pole of the World and the Horizon; therefore because the Plane falleth between the North Pole and the Horizon, therefore the North Pole is elevated above it; from whence you may conclude that the Center of the Dial must be downwards upon the Plane, and the Hour-lines running upward to the North Pole.

*Example, Let the Latitude of the Place be 51 30  
The Declination of the Plane be 33 00  
The Reclination of the Plane be 55 00*

**I. To find the Latitude of the Place wherein this Plane stands as an upright Decliner.**

|                                  |       |          |
|----------------------------------|-------|----------|
| As the Radius                    | 90 00 | 10,00000 |
| Isto the Co-sine of the old Dec. | 30 00 | 9,93753  |
| So is the Co-Tan. of the Decl.   | 55 00 | 9,84522  |
| To the Tangent of                | 31 14 | 19,78275 |

The Difference between this Tangent and the Latitude 51 30, is 20 16, whose Complement 69 44, is the New Latitude.

**II.** The referring of this Plane to a New Latitude, doth alter the Declination; therefore a new Declination must be found.

As

As the Radius, 90 00 10,00000  
 Is to the Co-sine of the reclina. 55 00 9,75859  
 So is the sine of the old Decl. 30 00 9,69897  
 To the sine of the new Decl. 16 40 19,45756

Having found the new Latitude and new Declination, you may find the *Substile* distance from the *Meridian*, the *Stiles* height, and the Planes difference of Longitude, as you were directed for upright Decliners. — Only Note, Instead of using the Old Latitude and Declination, you must use the new Latitude and Declination.

The distance of the Meridian and Horizon may be found by the Directions of the 12th Chapter, Page 98.

|                                      |    |    |
|--------------------------------------|----|----|
| Old Latitude.                        | 51 | 30 |
| Old Declination.                     | 30 | 00 |
| Reclination of the Plane.            | 55 | 00 |
| New Latitude.                        | 69 | 44 |
| New Declination.                     | 16 | 40 |
| Substiles Distance from              | 06 | 03 |
| Sales Height.                        | 19 | 29 |
| Planes Longitude.                    | 17 | 43 |
| Meridians Distance from the Horizon. | 64 | 41 |

| Hours from the Substile. | Equinoctial Distances. | Hour Arches. | Hours from the Substile. |
|--------------------------|------------------------|--------------|--------------------------|
| East Dial.               | D. M. S.               | M. S.        | West Dial.               |
| 5                        | 87 00                  | 22 82        | 07                       |
| 6                        | 73                     | 22 46        | 17                       |
| 7                        | 57                     | 22 27        | 26                       |
| 8                        | 42                     | 22 16        | 52                       |
| 9                        | 27                     | 22 09        | 46                       |
| 10                       | 12                     | 22 04        | 10                       |
| Substile.                |                        |              | Substile.                |
| 11                       | 02                     | 38 00        | 53                       |
| 12                       | 17                     | 38 06        | 02                       |
| 1                        | 32                     | 38 12        | 01                       |
| 2                        | 47                     | 38 20        | 01                       |
| 3                        | 62                     | 38 32        | 42                       |
| 4                        | 77                     | 38 56        | 35                       |

Having found the Requisites, you may frame a Table of Angles at the Pole, according to the Direction of Upright Decliner. From thence you may find the Hour Arches, and set them down as you see in this Table.

## The Geometrical Projection.

1. Draw the Horizontal-line A B, then on G the Center, with 60 deg. of Chords, describe the Circle AEB, then take 64:41, the distance of the *Meridian* and *Horizon*, and set from B to C, because the Plane declines Eastward, and draw the Line G C, for the *Meridian* or 12 a Clock; then take 06:03, the Substiles distance from the *Meridian* and set from C to D, on the Right-hand of the *Meridian*, because the Plane declines Eastwards, also take 19:25, the Stiles height and set from D to E, and draw G E, for the Substile, and G E, for the Stile.

Then from the same Line of Chords you described your Circle AEB, take 82:07, 46:17, 27:26, 16:52, 09:46, 04:10, and set from the *Substile* D, for the Hours of 5, 6, 7, 8, 9, and 10 in the Forenoon: Then take 00:53, 06:02, 12:01, 20:01, 32:42, 56:25, and set from D, the *Substile*, for 11, and 12 at Noon, and 1, 2, 3, 4, in the Afternoon, and from C, the Center of your *Dial* draw Lines thro' the several Points, you have the Hour-lines desired.

Lastly, Let the Stile make an Angle of 19:25, above the Plane, and be set perpendicular to the Substiler-line G F, and raise the Plane to make an Angle of 35 deg. above the *Horizon*, and declining *East*, 30 deg. it will shew the true Time of the Day: Wherein note, That having made this one Dial (or any of the like) you have at once made four, changing but the Position of the *Dial*, and altering the number of the Hours, as the *Plane* doth require, For first, this answereth to the



the opposite *North* declining 38 deg. *West*, and Inclining to the *Horizon*, 55 deg. also the *South* declining *West*, 30 deg. and reclining 55 deg. and to his opposite *North* declining *East* 30 deg. and reclining 55 deg.

And note, In all *South* Recliner more than an *Equinoctial* the *Meridian* doth ascend above the *Horizontal* line, at the end which lies the same way with the Planes Declination.

And in all *North* Inclining Declining Planes more than the *Equinoctial*, the *Meridian* doth descend below the *Horizontal* line, at that end which lies the same way with the Planes Declination.

Those *South* Planes are *Equinoctial* Decliners, whose Reclination, and Declination maketh them fall into the Pole of the World, that is, the Plane doth pass thro' both Polar, and by that reason the *Stile* doth make no Angle with the Plane, but doth lie parallel to it, and those Planes, are said to be less than *Equinoctial* Planes that pass between the *Zenith* and the *Pole*, and those more than *Equinoctial* Planes that pass between the *Pole* and the *Horizon*.

Note, That in the Operation (in *South* Planes) in finding the New Latitude, if that the *Tangent* that comes out be equal to the Latitude of the Place, that Plane is said to be an *Equinoctial* Plane; but if more than the Latitude, it is less than an *Equinoctial* Plane, but if less than the Latitude, then is it more than an *Equinoctial* Plane.

made for changing the Position of the Dial, and altering the number of the Hours, as the Dial is directed, for this purpose, S E C T.

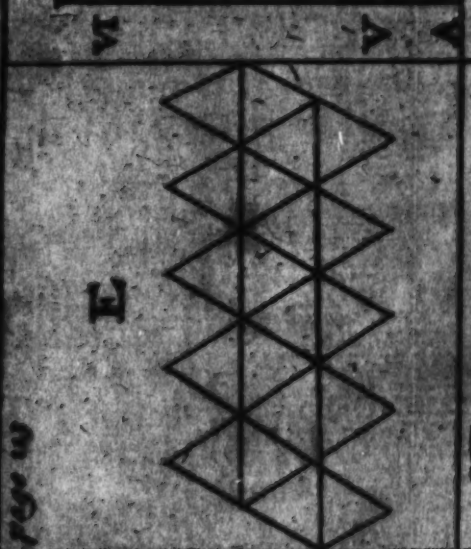
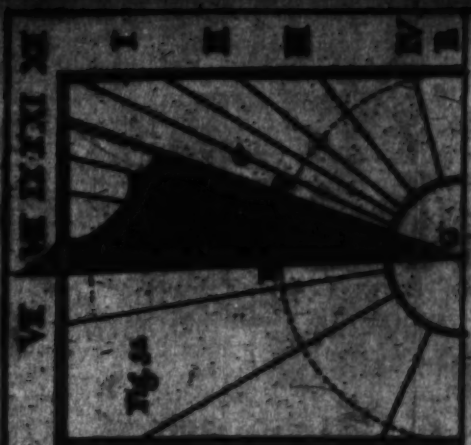




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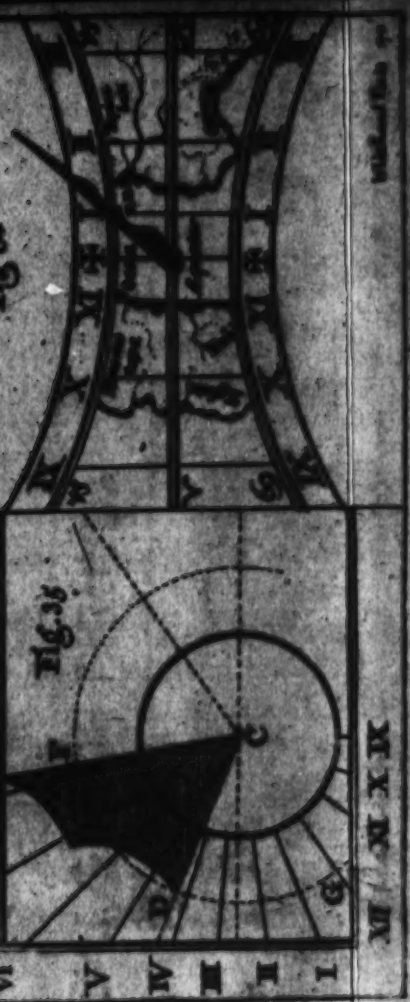


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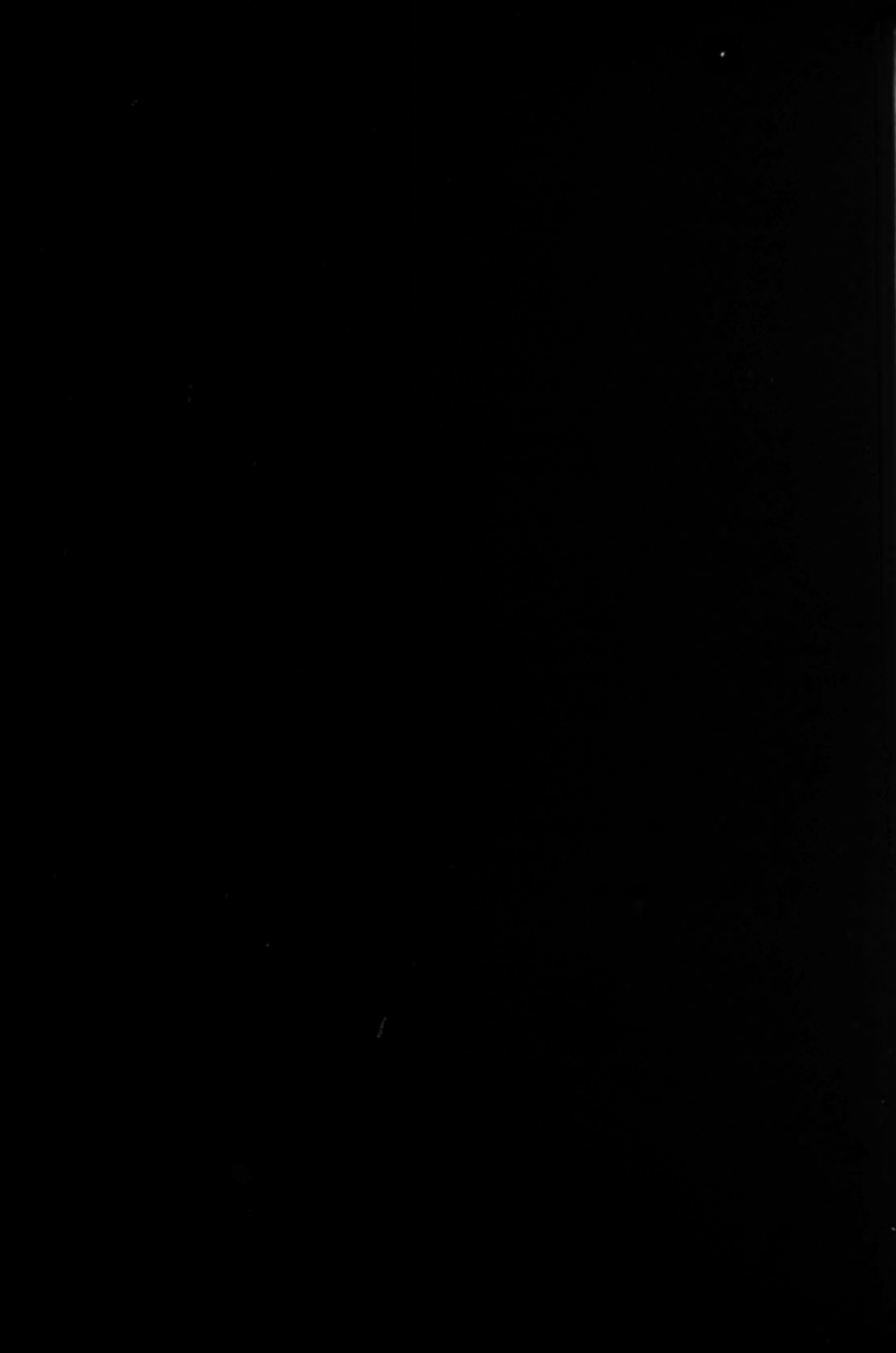


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Fig. 36







## S E C T. I.

The Latitude of the place, the Sun's Declinations with the Declination, and reclinacion given, to find what time the Sun forsaketh the South reclining Plane, to shine upon the North reclining opposite thereto.

**A**s the Radius 90 00 10,00000  
Is to the Tan. of the S. decl. 23 30 9,63836  
So is the Tan. of the Stiles heig. 19 25 9,54713  
To the Co-sine of 81 11 19,18543

Unto this Co-sine 81 11. add the Planes Longitude 17 42, the whole Angle is 98 53—90 deg. is 6 hours, therefore 08. 53. resolved into time giveth no Hours, but 35 min. before 6 at Night, when the Sun in Cancer forsaketh the Plane reclining, to Shine upon the Inclining side thereof, or again the Co-sine 81 11. resolved into time giveth 5 Hours 25 min. from Noon, that the Sun in the Morning, parteth with the North Inclining Plane, to Shine on the South reclining Plane, opposite thereto. Thus I have done with South reclining Dials.

## Of North Recliners.

## C H A P. XVI.

Fig. 21

How to draw Hour-lines, upon a North Reclining Declining Dial 60 deg. Westward, and Reclining 16 deg. from the Zenith toward the Equinoctial.

1. To find the New Latitude.

As the *Tan.* of the Planes reclamation 16,30  
*C. Arithmetical* ————— 0,54250  
 Is to the *Radius* ————— 90 00 10,00000  
 So is the *Co-sine* of the Planes decl. 60.00.9,69897  
 To the *Co-Tangent* of ————— 29 50 19,24147

This *Co-Tang.* being compared with the Latitude,  
 51. 30, there difference 21. 40, is the new *Latitude.*

2. To find the New *Declination.*

As the *Radius* ————— 90 00 10,00000  
 Is to the *Sine* of the *Declination*, 60 00 9,93753  
 So is the *Co-sine* of the *Reclina.* 16 00 9,98284  
 To the *sine* of the New *declina.* 56 40 19,92127

3. To find the distance of the *Mer.* and *Horizon.*

As the *Radius* — — — 90 00 10,00000  
 Is to the *Sine* of the *Reclinat.* 16 00 9,44033  
 So is the *Tangent* of the old decl 60 00 10,23856  
 To the *Co-Tan.* of the dist. }  
 of the *Meridian* and *Horizon*, } 64 29 19,67889

The *Latitude* of the Place ————— 51 30  
 The *Reclination* of the Plane 16 00  
 The decl. of the Plane from the *North West*. 66 00  
 The New *Latitude* ————— 21 40  
 The New *Declination* in that *Latitude*, 56 21  
 The distance of the *Mer.* and *Horizon*, 64 29  
 The distance of the *Substile* from the *Mer.* 64 28  
 The *Stiles* height above the Plane, 30 59  
 The Planes difference of *Longitude* 76 10

Having found these things, as you were directed  
 formerly,

formerly, you may proceed to the making of a Table of *Equinoctial Distances*, and so calculate the true Hour Distances, as you were Taught in upright Decliners, and they will be as followeth.

### The Geometrical Projection,

Draw an Horizontal-line almost in the Middle of the Plane, as AC, B, then chule a place in the Horizontal-line for a Center, as at C, and with 60 deg. of Chords make the Circle ABG, from the East Point of the Horizontal-line, A, by help of a line of Chords, set A, 12:64, 29, the distance of the Meridian, and Horizon, for the North part of the Meridian, or more properly from

| West Decliner. | Equinoctial Distances. | True Hour distance. | East Decliner. |
|----------------|------------------------|---------------------|----------------|
| Hours.         | D. M.                  | D. M.               | Hours.         |
| 1              | 88 50                  | 87 44               | 11             |
| 2              | 73 50                  | 60 37               | 10             |
| 3              | 58 50                  | 40 24               | 9              |
| 4              | 43 50                  | 26 18               | 8              |
| 5              | 28 50                  | 15 49               | 7              |
| 6              | 13 50                  | 7 13                | 6              |
| Substile.      |                        |                     | Substile.      |
| 7              | 1 10 0                 | 36                  | 5              |
| 8              | 16 10 8                | 29                  | 4              |
| 9              | 31 10 17               | 18                  | 3              |
| 10             | 46 10 28               | 12                  | 2              |
| 11             | 61 10 43               | 5                   | 1              |
| 12             | 76 10 64               | 26                  | 12             |

B, the West point of the Horizontal-line upwards to D, the South part thereof, and draw the Line DC, 12, for the 12 a Clock Hour-line; from D to E, set 64:21, the distance between the Substile and the Meridian Eastwards from it, and draw the pricked line CE for the Substile, from



the point *E*, in the Substile, by help of a Line of Chord, set off the True Hour distances both ways in the Circle towards *G*, and *D*, as you find them in your Table; unto every prick draw streight Lines from *C*, to the Centre, so shall you have all the hour-lines proper for this Dial.

Lastly, from *E*, to *F*, set off the height of the stile 30:59, and draw the Line *C, F*, representing the *Axis*, which being erected at right Angles over the Substile *C, E*, and must point upwards toward the North Pole, so is the *Dial* fit for Use, and must be placed according to the Declination and Reclination of the *Dial*.

Note, In Declining Reclining less than a Polar, the Meridian ascends above the Horizontal Line, the same way with the Coast of Declination, and represents 12 a Clock at Night; and in the South Declining Inclining Dial less than a Polar, the Meridian doth ascend below the Horizontal Line the same way with the Declination.

## S E C T. I.

How by having the Lat. of the Place, the Sun's Declination, the Declination and Reclination given, to find what Line the Sun parteth from the South Incliner, to Shine upon the North Recliner, opposite thereto.

|                                    |       |          |
|------------------------------------|-------|----------|
| As the Radius                      | 90    | 10,00000 |
| Is to the Tan. of the Sun's decl.  | 23 30 | 9,63830  |
| So is the Tan. of the Stiles heig. | 30 59 | 9,77848  |
| To the Co-Sine of                  | 74 52 | 19,41678 |

Out of the *Planes* Long. 76; 19, take 74: 52, there will remain 1 deg. 18 min. which converted into Time, giveth only 5 min. before Noon, when the *Sun* forsaketh the Inclining side of the *Plane*.



C H A P. XVII.

Fig. 34.

*How to draw Hour Lines upon a Polar Dial, Declining East or West 60 deg. and Reclining 32:11.*

**B**Efore I shew how *Hour Lines* are to be described on these *Dials*, I shew, how having a *Declination* given, to find a *Reclination* that will make it a *Polar Declining Dial*: Or having the *Reclination* given, to find what *Declination* will do the like.

### The Canon for Calculation.

AstheCo-Tan.oftheLat.Com.Arit.51 30 0,09939

Is to the *Radius* ————— 90 00 10,00000

So is the Co. Sine of the *Planes* De.60 00 9,69897

To the Tan. of the *Reclination*. 32 09 9,79836

Again,

As the *Radius* ————— 90 00 10,00000

Is to the *Tan.* of the *Reclination*. 32 09 9,79830

So is the Co Tan.of the Latitude 51 30 9,90060

So is the Co sine of the *De.* requ. 60 00 9,69890

In these sort of *Planes* you have only the height of the *Stile* above the *Substile*, and the distance

of the *Meridian* to find; now forasmuch as the distance of the *Substile* from the *Meridian* is 90: 00, and by that reason the *Plane* is an upright *Plane* where there is no *Latitude*, therefore the distance of the *Equator*, from the *Pole* being 90: 00, also; therefore the *New Declination* will be equal to the height of the *Stile*, which you may find by the following *Canons*.

As to the *Radius*. 90 00 0,00000  
 Is to the *Sine* of the *Planes Decl.* 60 00 9,93753  
 So is the *Co-sine* of the *Reclin.* 32 09 9,92770  
 To the *Co-sine* of the *Planes new De.* 42, 52 19,86520

Which is the *Height* of the *Stile* above the *Substile*; also you may find the distance of the *Meridian* and *Horizon* by this *Canon*.

As the *Co-Ta.* of the *Planes De. C. A.* 60 00 0,23856  
 Is to the *Radius* 90 00 10,00000  
 So is the *Sine* of the *Planes Recli.* 32 09 9,72602  
 To the *Co-Tangent* of 47 20 9,96458

The *Latitude* of the *Place* 51 30  
 The *Declination* of the *Plane* 60 00  
 The *Reclination* of the *Plane* 32 09  
 The *New Latitude* 00 00  
 The *New Declination* in that *Lar.* 42 52  
 The *Distance* of the *Substile* from the *Mer.* 90 00  
 The *Height* of the *Stile* above the *Plane* 42 52  
 The *Planes Difference* of the *Longitude* 90 00  
 The *Dist.* of the *Meridian* and *Horizon* 47 20

Hence you may see the *Planes Difference* of  
*Longitude,*

*Longitude*, being 90 deg. the *Substile* must be the 6 a Clock Hour-line, and the Hour Angles on either side of the Hour of Six is equal, therefore it is but the adding of 15 deg. on either side the *Substile*, and you have a Table of *Equinoctial Distances*, and from thence you may calculate the *True Hour*, as you were taught in *Upright Decliners*. The Table followeth.

### The Geometrical Projection.

The Table being prepared, draw the Horizontal-Line *A, C, B*, near the middle of the Plane and Parallel to the Bottom, in any Part thereof, at the Center *C*, with

| Hours from the Subst. | Equinoctial distance. | True Hours distance. | Hours from the Substile. |
|-----------------------|-----------------------|----------------------|--------------------------|
| Hours                 | D. M.                 | D. M.                | Hours                    |
| 6                     | Substile              | Substile             | 6                        |
| 5                     | 15                    | 10 20                | 7                        |
| 4                     | 30                    | 21 27                | 8                        |
| 3                     | 45                    | 34 14                | 9                        |
| 2                     | 60                    | 49 41                | 10                       |
| 1                     | 75                    | 68 30                | 11                       |
| 12                    | 90                    | 90 00                | 12                       |

60 deg. of Chords draw the Circle *H, G, E, F*, and set 47:20, the distance of the *Meridian* and *Horizon*, from *B*, the West End of the Horizontal Line to *F*, upwards, and draw the Line *F, C, D*, for the Hour of 12, then set 90 deg. the *Substiles* distance from the *Meridian*, from *F*, to *G*, and draw *C, G*, for the *Substile* and Hour-line of 6, set off from *G*, each way, by help of a Line of Chords upon the Circle *E, G, H*, the Hour distance, as you find them in the Table,



viz. for the *Hour* of 5, and 7, 10 deg. 20 min. for 4, and 8, 21 deg. 27 min. and so of the rest; (but past 8 you need add no more,) so shall you have *Points* unto which streight lines being drawn from the *Center*, are the true *Hour-lines* on the *Plane*.

Lastly, From *G*, either way set off the height of the *Stile* 42 deg. 52 min. from *G*, to *E*, and draw the line *C, E*, for the *Axis* of the *World*, which being erected perpendicular over the *Substile*, the *Dial* is finished; but observe that your *Dial* be set to its true *Declination* and *Reclination* proper to the same.

Note, The *Meridian* in all North Declining *Polar Dials*, descend below the *Horizontal-line*, at that End which is contrary to the Coast of the Declination: And the *Meridian* in all South Declining *Polar Dials*, doth descend also from the contrary Coast of Declination, and the six a Clock hour-line is always the *Substile* in both.

## S E C T. I.

The Latitude of the Place, the Declination of the Sun, together with the Reclination and Declination given to find what Time the Sun forsakes the South Inclining side, to shine upon the North Declining side, opposite thereto.

|                                    |       |          |
|------------------------------------|-------|----------|
| As the Radius,                     | 90 00 | 10,00000 |
| Is to the Tan. of the Sun's Decl.  | 23 30 | 9,63830  |
| So is the Tan. of the Stiles heig. | 42 52 | 9,96762  |
| To this Co-sine,                   | 66 12 | 9,60592  |

Out

Out of the *Planes* Longitude 90 deg. take 66.12, there will remain 23.48, which converted into time, giveth one hour 25 min. before Noon, when the *Sun* leaveth shining on the Inclining, and shineth upon the Reclining side.

## C H A P. XVIII. Fig. 35.

*How to draw the Hour-Lines upon a North Dial declining 60 deg. West, and reclining 54 deg. which cutteth the Meridian between the Equinoctial and the Horizon.*

THE making of this *Dial* differeth little from the former, therefore find the Requisites as you did in the former, that is first the New Latitude and New Declination find the distance of the Meridian and Horizon, and the Substiles distance from the Meridian, the Stiles height above the Plane, the *Planes* Longitude; and Hours distances as you have been taught in the former Chapters.

I shall not trouble you with Calculating the Requisites from this Plane; because they may be found by the last Chapter but one, and therefore it is needless to say any more about them, but they are Calculated, and are as followeth.

|                                           |    |       |
|-------------------------------------------|----|-------|
| The Latitude of the Place                 | 51 | 50    |
| The Declination of the <i>Planes</i> West | —  | 60 00 |
| The Reclination of the Plane              | —  | 54 00 |
| The Plane's new Latitude                  | —  | 18 30 |
| The Plane's new Declination               | —  | 30 36 |

The

The distance of Meridian and Horizon 35 31

The Sub. distance from the Mer. 123. 09. or 56 41

The Stiles height 54 46

The Plane's Longitude 118 13, or 61 47

Having the Plane's difference of Longitude, you may frame a *Table* of Equinoctial distances, and find the Hour distances, and place them as in this *Table* following.

### The Geometrical Projection.

| Hours.    | Equino-<br>ctial di-<br>stance. |    | True<br>Hour<br>distance. |    | Hours.    |
|-----------|---------------------------------|----|---------------------------|----|-----------|
|           | D.                              | M. | D.                        | M. |           |
| 12        | 61                              | 48 | 56                        | 41 | 12        |
| 11        | 46                              | 48 | 40                        | 49 | 1         |
| 10        | 31                              | 48 | 26                        | 50 | 2         |
| 9         | 16                              | 48 | 13                        | 50 | 3         |
| 8         | 1                               | 48 | 1                         | 97 | 4         |
| Substile. |                                 |    |                           |    | Substile. |
| 7         | 13                              | 12 | 10                        | 51 | 5         |
| 6         | 28                              | 12 | 23                        | 39 | 6         |
| 5         | 43                              | 12 | 37                        | 29 | 7         |
| 4         | 58                              | 12 | 52                        | 48 | 8         |
| 3         | 73                              | 12 | 69                        | 43 | 9         |

Draw the Horizontal Line D, C, A, about the middle of the Plane, Parallel to the bottom, then at C, as a Centre with 60 deg. of Chords describe the Circle F, D, G, and from the East point of the Horizon from B, to G, set 35. 31. the Distance of the Meridian and Horizon, and draw the Line C, G, for

the Twelve a Clock hour Line, then set off 56 41. the Substiles distance from the Meridian from G, to D, and draw the Line C, D, for the Substile, and set off 54 46 from D, to F, for the Stile, so shall D, F, be the Stiles height above the Plane; then

then set the *Hour* distances from the *Substile* both ways, as you find them in the *Table* (as you have been taught in the foregoing Chapters) and thro' the Points draw Lines, and set the *Stile* right over the *Substile*, and then you have finished four several *Dials*. This for one, and his Opposite Inclining 54 deg. to the *Horizon*, and Declining East 60 deg. and his opposite South Inclining 54 deg. and Declining 60 deg. West, only turning the *Dials* upside down, and changing the Figures of the *Hours* for Forenoon and Afternoon, as the *Dials* will direct you; and so may be done to all *Dials* whatsoever, except the direct East, or West, for there can be but two, for the back-side of the East, is the West.

Note, The Meridian in all North Recliners more than at Polar (as this is one) doth ascend below the *Horizontal-line*, and from that End which lies contrary to the Coast of the Plane's Declination, and in the South Inclining and Declining more than a Polar, the Meridian doth ascend above the *Horizontal-line*, contrary to the Coast of the Declination, and is only serviceable to draw the Dial.

Note also, In the North Reclining Declining *Dials*, if that Tangent that comes out in finding the new Latitude be equal to the Complement of the Latitude of the Place, then is that a Polar Plane, if the Complement of the Latitude exceed the Tangent, then is the Plane less than a Polar, but if the Tangent found, doth exceed the Complement of the Latitude, then is the Plane more than a Polar-Dial.



## S E C T. I.

*Having the Latitude of the Place, the Sun's Declination, with the Declination, and Reclination of the Plane, given to find what Time the Sun forsaketh the South Inclining side to shine on the North Reclining side Opposite.*

|                                    |       |          |
|------------------------------------|-------|----------|
| As the Radius,                     | 90 00 | 10,00000 |
| Is to the Tan. of the Sun's Decl.  | 23 30 | 9,63839  |
| So is the Tan. of the Stiles heig. | 54 43 | 10,15021 |
| To this Co-sine of                 | 52 05 | 19,78851 |

Unto the Angle 52:25, add the Plane's Longitude 61:47, from the North, or out of the Angle 118:13, counted from the South, there remains 66:08, which converted into Time, giveth 4 Hours, 14 Min. before Noon, when the Sun forsaketh the Inclining side of the Plane, and shineth upon the Reclining side thereof.

## C H A P. XXI. Fig. 12, &amp; 13,

*Directions for making Two Sorts of SPOT-DIALS, very useful to shew the Hour within the House.*

*A Description of the Spot-Dial.*

**T**HE Spot Dial, is of two sorts; in the one a bright Spot goes to the Lines, in the other the Lines go to a black Spot; the former being explained,

plained, the latter cannot be unknown. The manner of drawing the Hour-lines, is the same was shewed on any other Dials, in the foregoing Chapters ; but consider, if there was an Axis or Stile on this Dial, it would pass through the Back-board (which all such Dials must have) and the very Point where the Axis doth go through, is the Place where a hole in the one, and a spot in the other is to be made, that at any time (the Sun shining) will shew you the Hour of the Day.

## S E C T. I.

### *For the making of these Dials.*

1. Get the Joynerto make you a moulded wooden Frame, with miter-joynts, like the frame of a Looking-Glass, or such a Gilt Frame, as are made for Pictures; about 8 Inches long, 5 Inches broad, and an Inch and half thick, and nail upon one of the longest edges of the Frame a piece of thin Board a little longer than the Frame, and but half as broad: This piece of Board is for the bottom, and be sure that your Frame stands exactly perpendicular upon the bottom piece: Then for the back of your Frame, get a thin plate of Wood, exactly fit for it, and at the top of this Plate of Wood make a hole about 3 Inches long, and two Inches broad, and upon that nail a piece of Tin, or rather Copper-Plate.

2. You must get a piece of Crown Glass fit for your Frame, and grinde one side of it till it is as lucid as Paper, thus: Lay your Glass upon a Linnen,

nen, or Woollen Cloth to keep it from breaking; then with a small piece of Glass, and *Calice-Sand* grinde your Glass, but you must have a great care not to grinde the other side; for in little time you may so smutch the Glass by heedless mistake of the side, as to make it useless.

3. Having found the Declination of your *Glass-Window*, against which it is to stand, make a Dial exactly the bigness of your Glass upon Paper, to that Declination, with *Stile* and *Substile* drawn upon the Paper, as if you were to make it for the Wall without Doors, or outside of the *Window*: but the Figures of this *Paper Dial* must be inverred, or made backward as in Figure 13; and if you Write in *Roman Letters*, for Nine you must Write Eleven; and therefore your best way is to have a Copy before you, of Figures so drawn.

4. Now to find where the Spot will be; remember that it will be always in the *Substile*, and as far distant from the *Stile*, as is the distance between your Glass and the Tine. Put therefore your Glass already ground, into the Frame, and take the nearest distance between your Glass and Tin; for this end make a square of Paper; and applying one side to the Glass as it lies in the Frame, make a point at the nearest distance, and clip off the rest of the Paper at that point; with that distance come to your Dial on the Paper, and lay the longest edge of this square to the *Substile*, and carry it backward or forward upon the *Substile*, till the marked point just toucheth the *Stile*; then holding it, draw a line from the *Substile* to the *Stile*, and mark that point upon the *Paper-Dial*, where this Line cutteth the *Substile*, viz. at the corner of the

the Square (which I call the *Substile-point*) and draw a round  about it, that you may know it again.

5. Having drawn your *Paper-Dial* the exact Bigness of your Glass, and found your *Substile-point*, you must draw the Hour-lines upon the rough side of the Glass, thus: Wet the Figured side of your *Paper-Dial* with Gum-Water, and lay it on the smooth side of your Glass; and when it is dry, set one Foot of your Compasses upon the Center of the *Dial*, and open the other to the *Substile-point*; with that distance describe a *Semicircle*, and from that *Semicircle* draw all your Hour-line with a Pen and Ink, by the side of a Ruler upon the rough side of the Glass; your Figures must be drawn wrong as they appear through the Glass, which you will find to be right when your Dial is in the Frame, and finish'd.

6. Mark your *Substile-point* upon your Glass, and take off your *Paper-Dial*.

7. Make fast your Glass in the Frame with small Tacks, the rough side next the *Back-board*.

8. Make a little hole in the Tin, perpendicular over against the *Substile-point*, which you will find by the *Paper-Square*; by which you may draw a perpendicular line from the *Substile-point*, and Ink it upon the Top of the Frame, and so draw it down your *Back-board*; then take the distance from the *Substile-point* to the outermost Edge, or Top of the Frame, and set it upon your line drawn on your *Back-board*, from the Top downwards, which distance will be perpendicular over your *Substile-point*.

9. And lastly, With *White-lead* and *Linseed-Oyl*



Oyl ground together, Paint the rough side of the *Glass*; then glue on your *Back-board*, and your *Dial* is finished.

Now your *Dial* being made, set it close to your *Glass-Window*, and the *Sun* entering thro' the little hole, will cast its *Ray* upon the opposite *Hour-lines*, and so give the time of the Day.

I need not say much of that Form, wherein the *Lines* go to the *Spot*, for it is but the same inverted, as if you should turn this upside down, and draw the *Lines* towards *Window* or *Street*, upon a clear *Transparent Glass*, and on the inside toward the *House*, instead of the *Plate of Wood*, and the *Tin*, you must have a *Glass* ground, with one black *Spot* at the bottom, where the hole is in the *Tin*, unto which *Spot* every *Line* will come successively, according to the time of the Day; and the *Figures* must be made upon the clear *Glass* at *Top*; and there must be a great square *Quarry* of *Glass* in the *Window* behind it, for the *Leads* will make a very unhandsome Confusion.

## S E C T. II.

How to draw *Hour-lines* upon the *Window-board*, *Walls*, and *Floor* of a *Room*, the *Sun* shining through a small *Hole* made in any *Pane* or *Quarry* of *Glass* in the *Window*.

First, if in the *Glass-Window* of any *Room*, one *Pane* or *Quarry* of *Glass* be darkned, and a *Hole* made about half a quarter of an *Inch* diameter in the middle thereof, the *Sun* shining upon the *Window*,

*Window*, will through that hole cast a bright *Spot* of *Light* into the *Room*, which as the *Sun* in his motion passeth by the *Window*, the *Spot* of *Light* will be also removed from place to place, sometimes upon the *Window board*, sometimes upon the *Jamb*s, sometimes upon the *Sides* and sometimes upon the *Floor* of the *Room*: If such a *Hole* should be supposed to be the *Nodus* or *Point* of the *Top* of the perpendicular *Stile* of any *Dial*, I say from it the *Hour-lines* of a *Sun-Dial*, or of several *Dials*, (for every side or part of the *Room* is a different *Plane*) may be made about the *Room* If,

1. *Horizontally* you apply an *Horizontal-Dial* to the *Hole* in the *Glass-Window*, and extend a thread *Horizontally* also from that *Hole*, over every *Hour-line* (or half and quarter *Hour-line*) till it touch the *Sides*, *Doors*, *Windows*, *Jamb*s, or other *Objects* or *Impediments* (standing in the way) about the *Room*: Then,

2. The *Twelve* a *Clock Hour-line*, being both an *Hour-line*, and an *Azimuth* also; you may (by a perpendicular *Thread*, or *Threads*.) transfer the same to the *Cieling* or *Floor* of your *Room*, or to which of them will best serve your *Turn*, and sometimes there may be occasion for both: Then,

3. In this *Meridian line* find any *Point*, from which a *Line* or *Thread* extended to the *Hole* in the *Window*, may represent either the *Direct* (or *Reverted*) *Axis* of the *World*, and unto that *Point* or *Points*; all the *Hour-lines* which you draw in that *Room* will have respect unto, (or be in the same *Plane* with) this *Axis*: and therefore,

4. If you fix a *Thread* in one or both of these *Points*,

*Points*, (or *Poles* rather) and extend that *String* by the side of another *String*, extended from the *Hole* over any *Hour-line* or *Point*, found on the side of the *Room* (as before) that moveable *String* being gently moved by the side of the *Horizontal String*, shall trace out (upon all *Objects* that it meets withal) the *Hour-line*, which the extended *Horizontal String* doth represent.

## CONCAVE DIALLING

### CHAP. XXII.

*How to draw Hour-lines in the Inside of Regular Concave Hemispheres.*

**T**Hese *Regular Concave Hemispheres* are the most natural *Planes*, upon which *Hour-lines* may be described; for they do naturally represent the *Sphere*; and the manner how the *Hour-lines* and *Furniture* may be described, into such *Dials*, shall be the Work of this and the next Chapter.

## SECT. I

Fig. 14.

*To make a Horizontal Concave Dial.*

**H**AVING a *Concave Hemisphere* prepared: as, S. N. E. W. divide the *Limb* into 4 *Quadrants*, noted as the former Letters; one of the *Quadrants* divided into 90 deg. open your *Compasses*

passes to the Quadrant, and setting one Foot upon E. or W. with the other, draw the *Meridian* or 12 a Clock *Hour-line* SZN take out of the Quadrant, the *Latitude* 51 deg. 30 min. and set those degrees upon the *Meridian* from S, towards Z to P, which P, shall be the *Pole* of the World; then placing your *Compasses* upon P, (they being opened to a Quadrant) draw the *Equinoctial Circle* FÆW, which divide into 12 equal Parts; your *Compasses* being opened as before to a Quadrant, and one Foot being placed in those Marks, made in the *Equinoctial*, with the other Foot describe *Circles*, which shall be the *Hour-lines* required; the *Stile* must be erected in P, with an Angle of 51 deg. 30 min. the *Latitude* of the Place; and equal to the length of 60 deg. of the Quadrant, the *Top* must hang over the Center of the *Hemisphere* Z, and be parallel with the Limb, or erect a *Stile* in the Point Z, of the same length with the former, which shall shew the hour with the *Top* only.

## S E C T. II.

*How to make a Direct South or North Concave Dial.*

**T**HIS Dial is made altogether like the former, only instead of setting off the *Latitude* from S to P, you must only set off the *Complement* of the *Latitude* 38 deg. 30 min. and the *Hour-lines* only from 6 to 6, are described thereon; the



rest of the Hour-lines, are reserved for a *Direct Dial* beholding the North.

### S E C T. III.

Fig. 15.

*How to make a Direct East or West Concave Dial.*

**L**ET the Hemisphere be ZSNG, the Limb being divided into four Quadrants, and one of them into 90 deg. from N, upwards, and from S, downwards, set the Latitude to P, then open your Compasses to a Quadrant, one foot being set in P, with the other draw the Circle QEA, which Circle divide into 12 equal Parts, your Compasses being opened to a Quadrant, one foot placed in each of these marks, with the other draw Circles, which shall be the *Hour-lines* required, as in Figure 15, The *Stile* may be a *Wire* laid from P to P, or a *Wire* erected in the Center E, equal to the Semidiameter of the Quadrant; for better Instruction see the Figure, which is an *East Dial*.

In the same manner is an Equinoctial Dial made, only all the hours from 6 in the Morning till 6 at Night, must be drawn, as the rest above those proper for the *East* or *West* Dials are, and as the pricked hours 9 17 and 6, in the Figure.

Also the Hour-line of 6, viz. the Line P 6 P, must be P 12 P, and the rest number'd as in the Figure is expressed, and number'd with *Arithmetical Figures*.

S E C T.

## S E C T. IV.

Fig. 16.

*How to make a South or North Declining Concave Dial.*

**Y**OUR Concave being prepared, quartered and marked with the Letters ZNEW, your Compasses being opened to a Quadrant, and one foot in Z or N, draw the Horizontal Circle ESW, take the Declination, and prick it down in the Horizontal Circle from W to H, one foot of your Compasses remaining in H, and being opened to a Quadrant, describe the Meridian, or hour of 12, in which from Z, set off the Complement of the Latitude, or from it's intersection with the Horizontal Circle, set off the Latitude to P, one foot of your Compasses being in P, and opened to a Quadrant, draw the Equinoctial QEA, and where it is intersected by the hour of 12, begin to divide it into 12 equal Parts, one foot of your Compasses being placed in each of these Points, and being opened to a Quadrant, draw Lines which shall be the Hour-Lines required. For the Stile, that must be erected in P, and the top of it must pass through the Center, of the Limb of the Concave, and be equal to the length of 60 deg. of the Quadrant, or you may erect the Stile, in the point S, the length equal to the former; which will shew the hour of the day with the very top of it.

Note, This Figure Declines West; which if it had

had declined East, the Declination must have been set from E.

---

## S E C T. V.

### *How to make a Polar Concave-Dial.*

**A** Polar Concave-Dial, is nothing but an Horizontal-Dial, in the Latitude of 90 deg. and of all others is most easie to be made, for if you divide the Limb of the Concave Hemisphere into 24 equal Parts, and from the Center of the Concave, (by help of a thin Ruler that will bend) draw streight Lines to each of them, those shall be the Hour-lines required.

For the *Stile*, it must be a streight Wire erected Perpendicular in the Center of the Concave, whose shadow will at all Times (the Sun shining) give the hour of the Day, and the hours of these *Dials*, must be numbred from 12 to 12.

---

## Of The FURNITURE in CONCAVE DIALS.

### C H A P. XXIII.

S E C T. I. *How to draw the Parallels of the Sun's Declination, in the foregoing Concave Dials.*

**T**HE Equator being drawn, set off the degrees of Declination from the Equator in the Meridian

*Meridian* of the Concave or *Substiler*, both upwards and downwards; then place one foot of your *Compasses* in the Pole, and extend the other to those you marked from the *Equator*, draw *Circles*, which shall be the *Parallels* of the *Sun's Declination* required; As for *Example*, the drawing of the two *Tropicks*, which declines 23 deg. 30 min. from the *Equator*; take 23 deg. 30 min. and prick it down in the *Meridian* both ways, then place one foot of your *Compasses* in the Pole, and with the other extended to 23 deg. 30 min. describe the two *Tropicks*; as in *Figure 14.* appears.

---

## S E C T. II.

*How to draw the Azimuths or Vertical Circles.*

**D**ivide the *Horizon* into 180 deg. beginning where it's intersected by the *Meridian*; if you would draw every 10th *Azimuth*, then you may only divide it into 18 equal Parts, beginning at the same Place; but if you would only draw every 15 *Azimuth*, then divide the *Horizon* into 12 equal Parts, beginning as before at the *Meridian*; if you would draw the Points of the *Compass*, divide the *Horizon* into 16 Parts, then open your *Compasses* to a Quadrant, place one Foot in any of those *Divisions*, and where the other Foot intersects the *Horizontal Line*, shall be the Center for drawing that *Azimuth*.





How to draw Planetary or Unequal Hours.

**F**OR the drawing of the Planetary Hours, having first described the Horizon, Equator, and the two Tropicks, divide that part of the Tropick which is intercepted betwixt its intersection with the Horizontal-Circle, into 12 equal parts beginning at 12; the Equator being before divided into 12 equal parts by the Hour-lines, open your Compasses to a Quadrant, one foot being placed in one of those Divisions, move the other foot until you find the Center, which will draw both those Points into one Circle; and draw Circles which shall be the unequal Hours required.

#### S E C T. IV.

How to draw Hours from Sun Rise, to Sun Set, called the Italian and Babylonish Hours.

**P**Lace one foot of your Compasses in the Pole, and extend the other to the Intersection of the Horizon and Meridian, and describe the Parallel of the Latitude, which shall be divided into 24 equal parts by the Hour-circles, place one foot of your Compasses in each of those Divisions (the Compasses being opened to a Quadrant) the other foot, being placed within the Circle of Latitude, and in the Hour-circle, which passeth through the Point

*Points* where the *Compasses* is set in the *Circle* ; making that the *Center*, describe *Circles* from one *Tropick* to another, which shall be the *Hour-lines* from *Sun rise* to *Sun set* ; and shall pass by the *Intersection* of the *Hour-lines* and the *Equator*.

## SECT. V.

### *How to draw the Almicanter.*

HAVING found the *Points* of *Zenith* and *Nadir*, the distance of these *Points* to the *Horizontal line* into 90 deg. one *Foot* being placed on one of these *Points*, the other extend to those *Degrees*, *Circles* drawn from one *Tropick* to another, shall give *Almicanter*s or *Circles* of *Altitude*.

## CONVEX DIALLING.

### C. H. A. P. XXIV.

*How to make a Dial, upon the Convex Superficies of a Globe which shall shew the Hour, by the Shadow, which separateth the Enlightened Hemisphere from the Opacus.*

THE Performance of this is very easy, for (the *Globe* being truly *Spherical*) if the *Equinoctial Circle*, the two *Tropicks*, and the two *Polar Circles* which will be necessary for ornaments only to be described thereon, and your *Equinoctial Circle*

side of the Globe.

to the other,

with Hemorrhoids from the Ovaries.

THEIR PERFORMANCE OF THIS IS VERY CREDITABLE

...the Globe being only 24 inches in diameter, and the two ...

Always be described them; and your Examination

**A TABLE containing the Latitude, of most of the Eminent Cities and Towns in England, Scotland and Ireland.**

| Places in England and Wales. | D. | M. | Places in Scotland and Ireland. | D. | M. |
|------------------------------|----|----|---------------------------------|----|----|
| LONDON                       | 51 | 30 | Rochester                       | 51 | 29 |
| York                         | 54 | 00 | Peterborough                    | 52 | 33 |
| Oxford                       | 51 | 34 | Chichester                      | 51 | 50 |
| Cambridge                    | 52 | 17 | Hertford                        | 51 | 51 |
| Norwich                      | 52 | 44 | Newark                          | 53 | 2  |
| Canterbury                   | 51 | 27 | Stafford                        | 52 | 55 |
| Bristol                      | 51 | 30 | Shrewsbury                      | 52 | 48 |
| Colchester                   | 52 | 4  | Lancaster                       | 54 | 8  |
| Glocester                    | 52 | 0  | Winchester                      | 51 | 10 |
| Hereford                     | 52 | 14 | Leicester                       | 52 | 40 |
| Monmouth                     | 51 | 51 | Pembroke                        | 51 | 46 |
| Yarmouth                     | 52 | 45 | Worcester.                      | 52 | 20 |
| Warwick                      | 52 | 25 | In Scotland.                    |    |    |
| Flint                        | 53 | 17 | EDENBURG                        | 55 | 56 |
| Salisbury                    | 51 | 0  | Glasgow                         | 55 | 52 |
| Northampton                  | 52 | 18 | St. John's                      | 57 | 44 |
| Newcastle                    | 54 | 58 | St. Andrew's                    | 57 | 45 |
| Lincoln                      | 53 | 15 | Sterling                        | 57 | 18 |
| Nottingham                   | 53 | 3  | Berwick                         | 55 | 49 |
| Boston                       | 53 | 2  | Aberdene.                       | 58 | 40 |
| Chester                      | 53 | 20 | In Ireland.                     |    |    |
| Wakefield                    | 53 | 54 | DUBLIN                          | 53 | 11 |
| Coventry                     | 52 | 30 | King'sale                       | 51 | 40 |
| Darby                        | 53 | 6  | Cork                            | 51 | 47 |
| Bedford                      | 52 | 18 | Wexford                         | 52 | 18 |
| Huntingdon                   | 52 | 99 | Waterford                       | 52 | 32 |
| Carmarthen                   | 52 | 2  | Limerick                        | 52 | 30 |
| Hull                         | 53 | 50 | Tredagh                         | 53 | 38 |
| Ipswich                      | 52 | 08 | King's-Town                     | 53 | 8  |
| St. David's                  | 52 | 0  | Queen's-Town                    | 52 | 52 |



## REFLEX DIALLING.

## CHAP. XXV.

**R**eflection is to be made by a piece of *Looking-Glass*, which is so much the better, by how much it is thinner; for the Thickness of it causeth a double Ray of Light to be reflected, and requires a greater Elevation of the *Sun's Beams* than a thin one doth: It must be about seven Times the Thickness in breadth; and because *Glass* reflects from upper and nearer *Superficies*, and so makes two *Spots*, colour the lower *Superficies* thereof with *Oyl Colour*, and it will make, but one *Spot*.

*How to make a Dial upon the Cieling of a Room, that is parallel to a piece of Glass, placed exactly Horizontal.*

**F**IRST, determine the most convenient Point in the Window where to place the *Reflecting Glass*, as near the *Cieling* as you can conveniently, provided it be not so near as that the Cornish of the Window will shadow the *Glass* when the *Sun* is high in Summer, suppose within 10 or a 11 Inches of the *Cieling*; then find a Point upon the *Cieling* directly over your *Glass*, thus: Hold a Line and Plummer to the *Cieling* just over it, and the Place where the Plumline toucheth the *Cieling* is the Point; then through  
this

this Point draw a *Perpendicular* to your *Window*. Now if your *Window* be exactly *South*, this *Perpendicular* upon the *Cieling* will be a *Meridian-line*; but if your *Window* declines the true *Meridian-line* will make an *Angle* with this *Perpendicular*, equal to the quantity of its *Déclination*. Therefore having found the *Déclination* of your *Window*, take 60 deg. of *Chords*, and setting one Foot in the Point on the *Cieling*, with the other describe a *Circle*, and set thereon (from the *Perpendicular*) the *Déclination* of your *Window*, toward your *Right-hand* if *West*, but toward your *Left-hand* if *East*; then draw a *Line* from the point on which you describe your *Circle*, which *Line* shall be your *Meridian-line*.

2. Draw an *Horizontal-Dial* upon the back of some *Table*, or some *Plaister-wall*, or *Floor*.

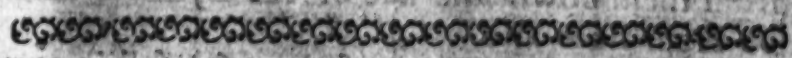
3. Take the distance between the *Glass* and the *Cieling* with your *Compasses*; then come to your *Dial* on the *Wall*, and lay one side of your *Square* to the *Meridian-line*, and the other crossing the *Stile*; then move the *Square* upon the *Meridian-line*, till the *Extent* of the *Compasses* does exactly touch both *Stile* and *Meridian-line*, and that point of the *Stile* which does touch the *Square*, may be called the *Glass-point*, from which erect a *Perpendicular*, and where it cuts the *Meridian-line* make a *Point*, which will be the *Equinoctial Point*, from which also erect a *Perpendicular*, which will be a *Tangent*; then at some distance on which side of the *Equinoctial Point* you find most convenient,





CYLINDRICAL DIALLING,

Concave or Convex.



CHAP. XXVI.

*Of those that fall in a Right Sphere, viz. such as lie Parallel to the Axis of the World, and their Bases Parallel to the Equinoctial.*

**H**OUR-lines may be drawn upon those Cylinders, with great Ease and Exactness, although in them there may be various Positions of the *Axis*.

*Sect. I.* If the *Axis* fall in the very Center of the Base of the Cylinder, then divide the Circumference of the Base of the Cylinder, in 24 equal Parts, and draw Lines from the Center to each of those Points, which will be the Hour-lines for the Base of the Cylinder: And where those Lines cut the Circumference Lines, drawn from them down the Cylinder's side, they shall be the true Hour-lines, which will be Parallel each to one another.

*Sect. II.* If the Point of the *Axis*, fall not just in the Center of the Base, of the Cylinder, thro' that Point where the *Axis* falls, and the Center of the Cylinder draw a Line, and with a Pair of Compasses take the nearest distance from  
the



the *Axis point* and describe a Circle, which divide into 24 equal Parts, (beginning at the Diameter first drawn) Lines drawn from the *Axis Point*, through every one of them, and extend to the Side or Circumference of the Base of the Cylinder, shall be *Hour-lines*, again Lines drawn from them down the side of the Cylinder shall be *Hour-lines* also.

*Sect. III.* If the Point of the *Axis* fall in any Part of the *Periferie* of the Cylinder's Base. Then divide the *Circumference* of the Cylinder's Base, into 12 equal Parts, beginning at the *Axis Point*; Lines drawn from thence to the several Points, in the *Periferie* of the Circle, and also down the Cylinder's side, they shall be the *Hour Lines*.

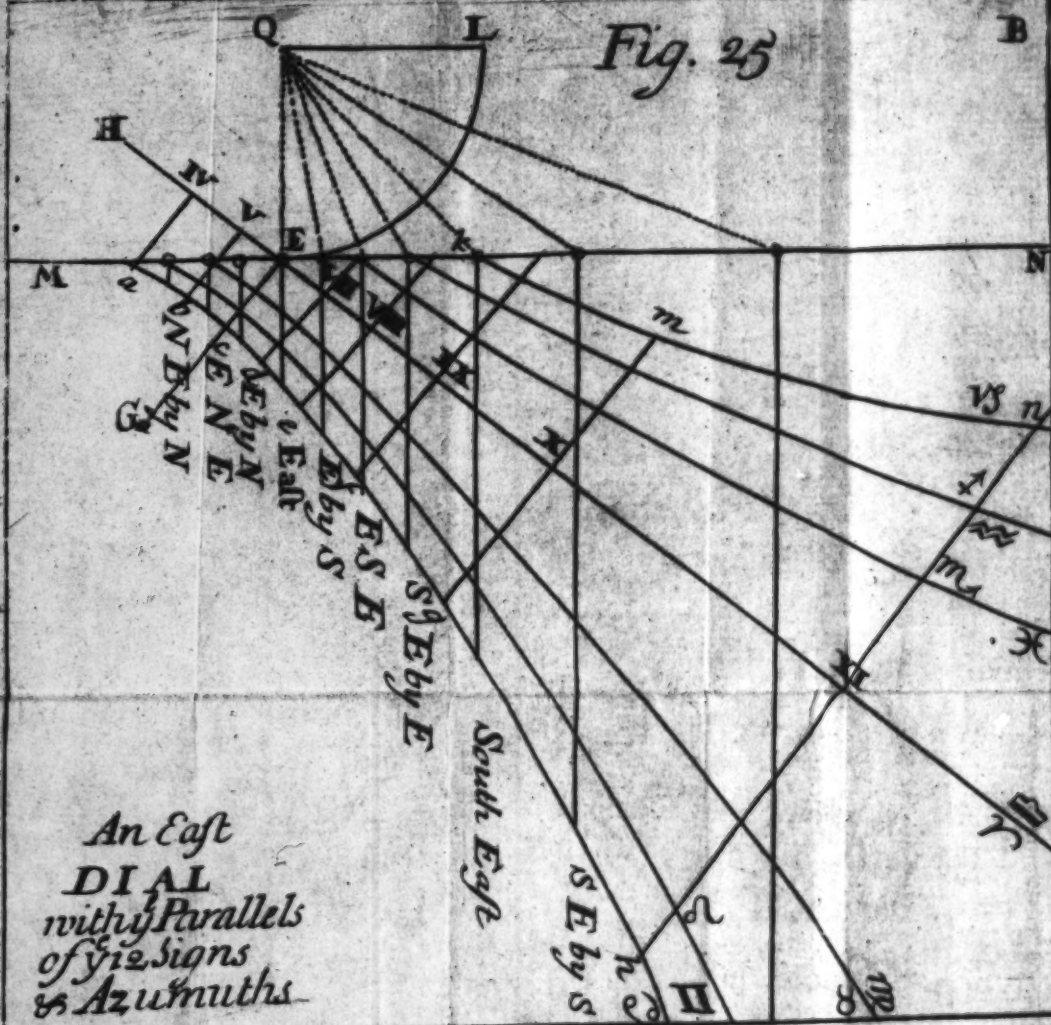
*Sect. IV.* If the *Axis Point* fall without the Base of the Cylinder. Then the distance between that Point, and the nearest Part of the *Periferie*, of the Cylinder's Base, being made Radius, and a Circle be thereon described, and divided into 12 equal Parts; then Lines drawn from the *Axis Point*, through those Divisions shall each of them cut the *Periferie* of the Cylinder's Base, in two Points, from which Lines drawn from one to another (each to this correspondent) they shall be the *Hour-lines*, and from them Point lines down the Cylinder's side, must parallel Lines be drawn.

Also,

*Sect. V.* If the Point of the *Axis* fall in the Center of the base of the Cylinder, first in the Center of the base, and the Point where the *Axis* falls, and with a Center of the Cylinder draw a Line, and with a Pair of Compasses take the nearest distance from  
of

1

Fig. 25



The Trigon  
Fig. 26

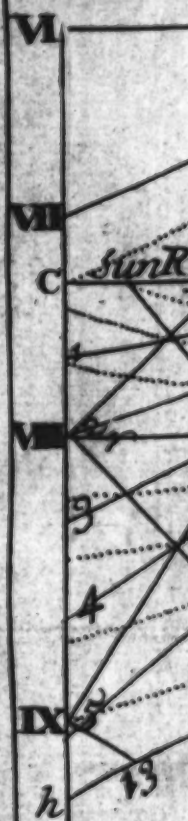
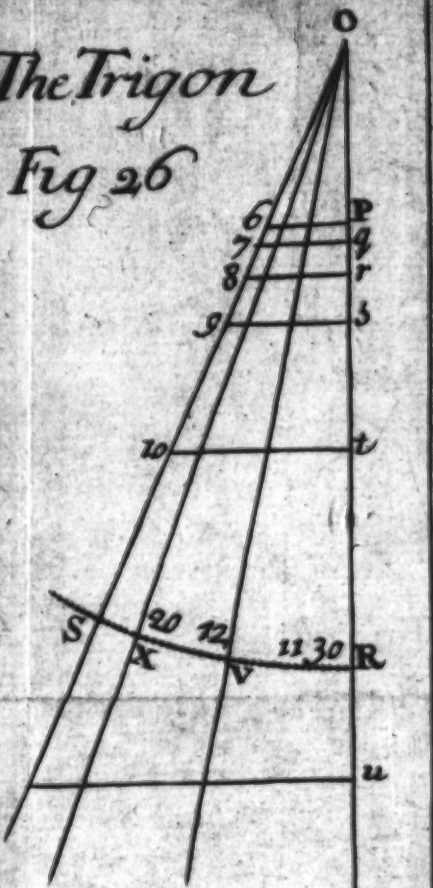


Fig. 29

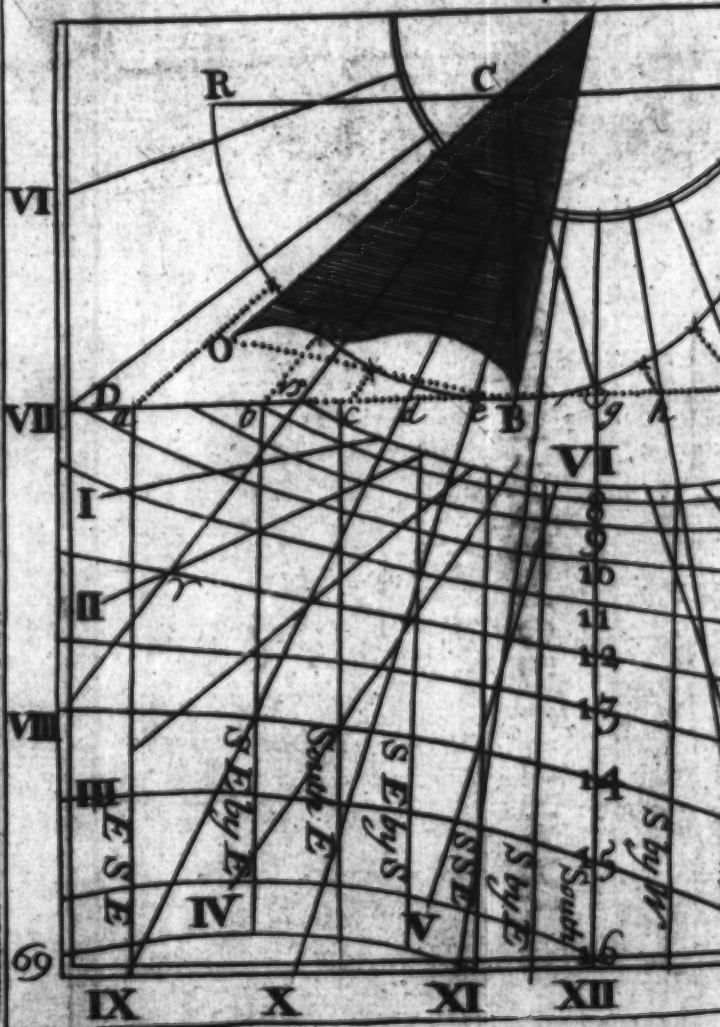
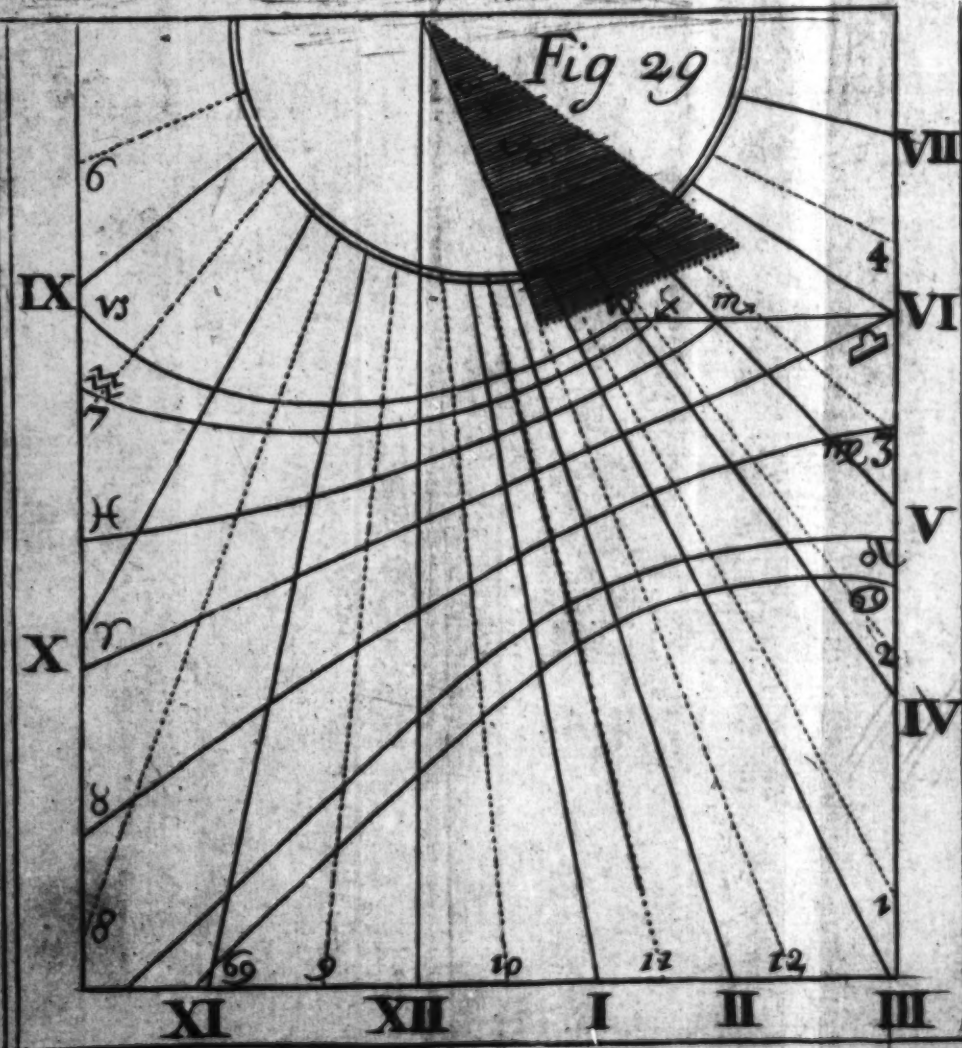




Fig 27

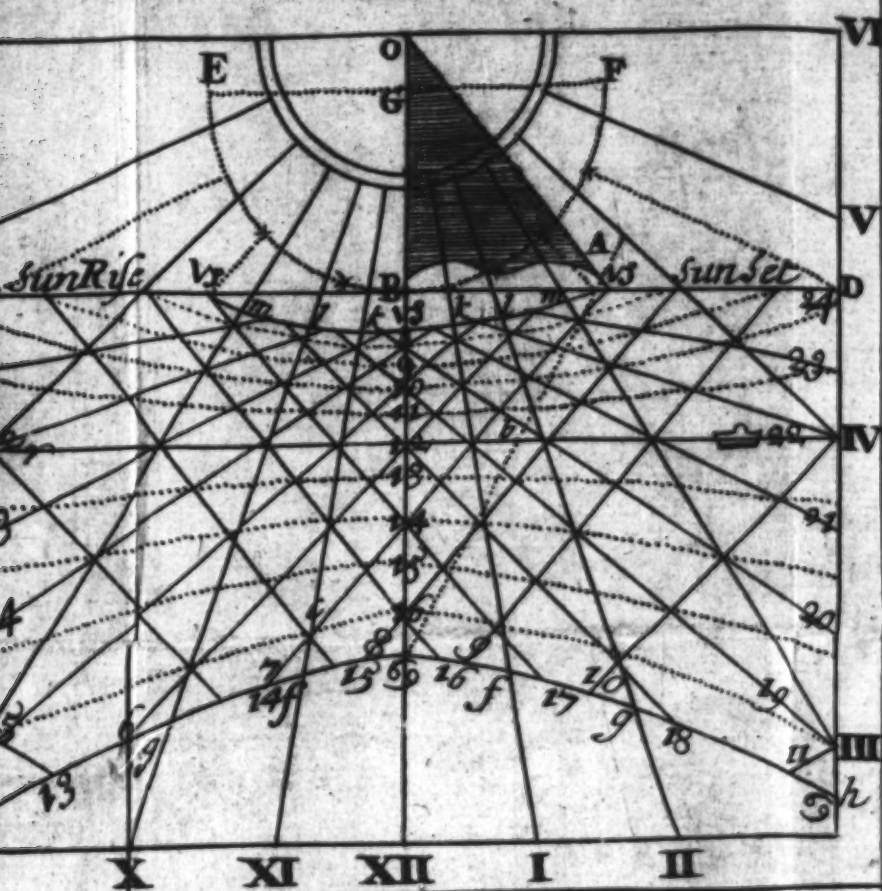


Fig 28

Trigon

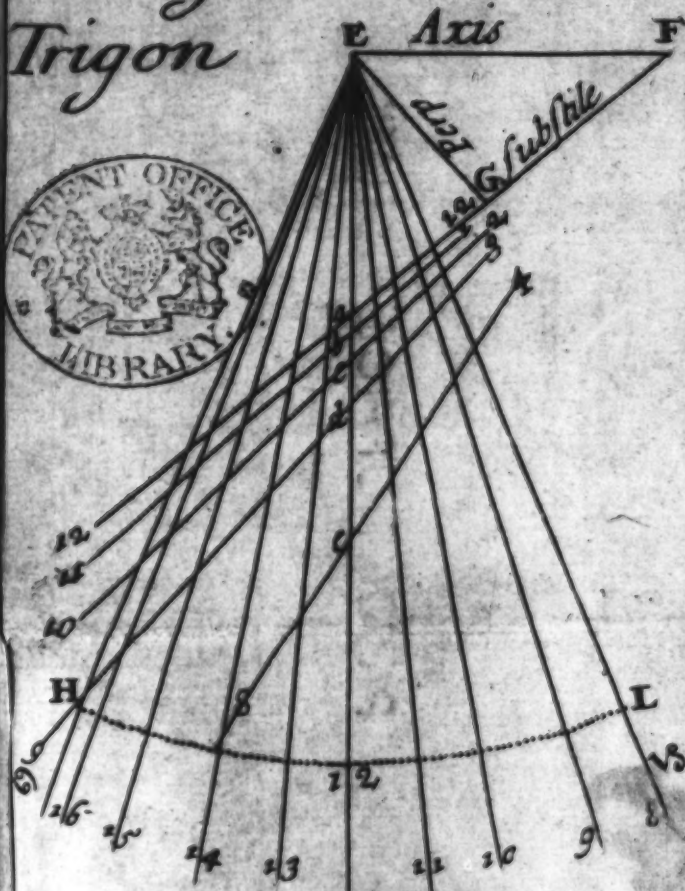


Fig 30

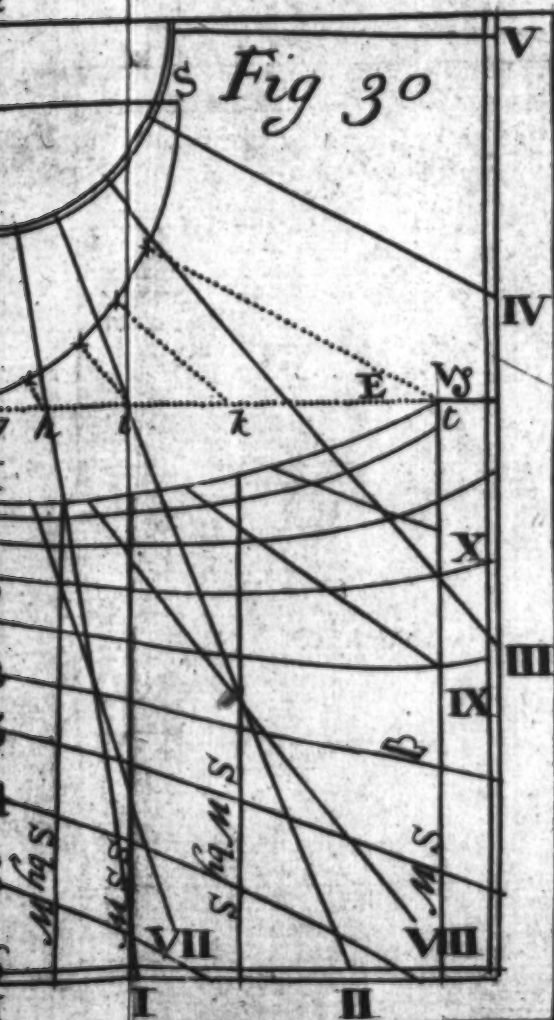
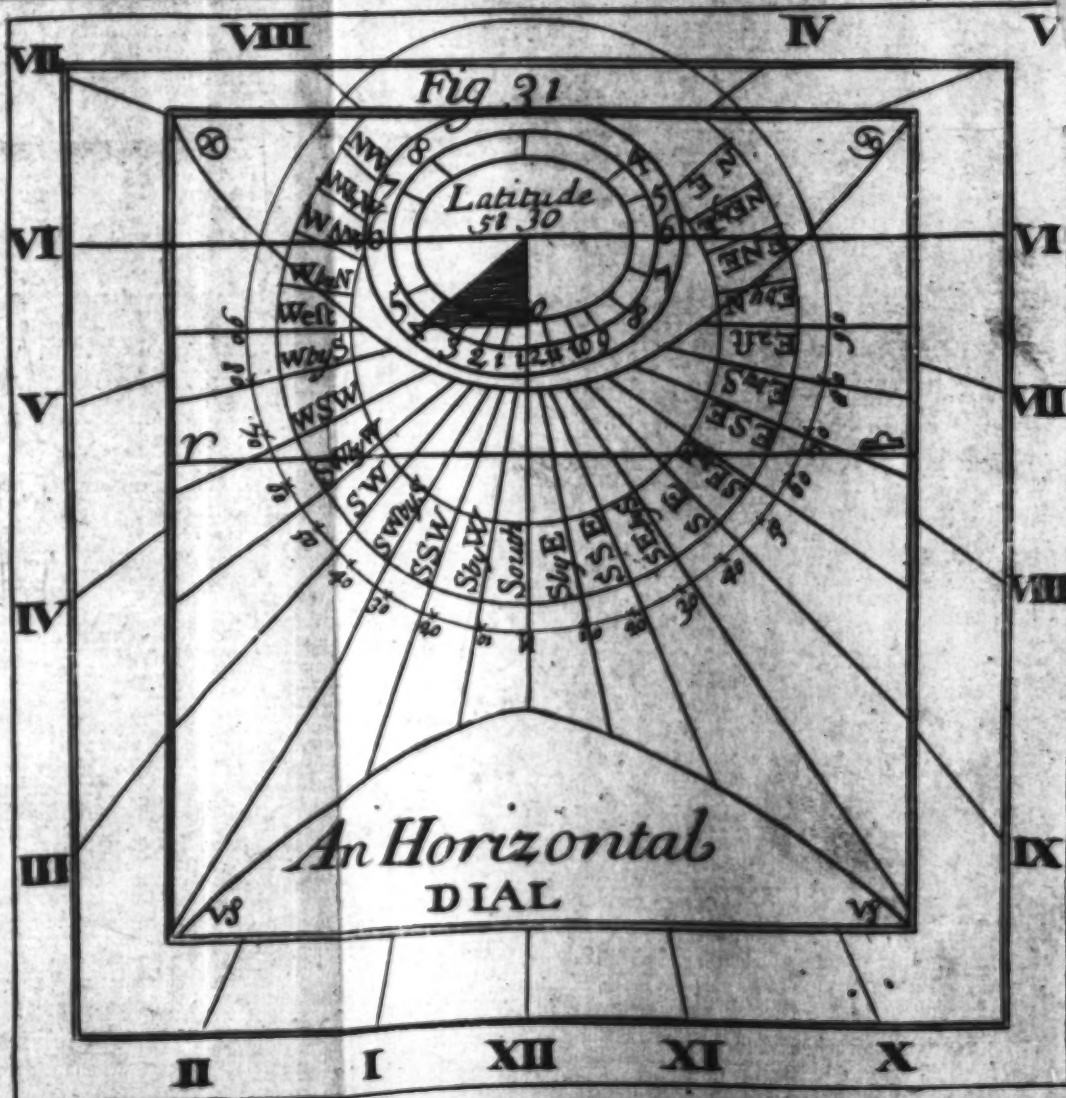


Fig 31







*Of the Furniture with which*

## Sun Dials

May be **BEAUTIFIED;**



*How to describe such Furniture upon all Sorts of Upright, Direct and Declining Dials; Geometrically.*

### CHAP. XXVII.

*Of such Circles of the Sphere, as are described upon Sun-Dials.*

**M**Any Astronomical Conclusions, may be performed by describing of the Circles of the Sphere upon *Sun-Dials*: Of which I have made choice of these following.

1. The *Parallels of the Signs*, shewing in what part of the *Zodiack* the *Sun* is, at all times of the Year.

2. The *Diurnal Arches*, shewing the length of the Day throughout the Year.

3. The *Hours* from the *Sun's* Rising or Setting, or otherways called the *Babylonish* and *Italian Hours*.

4. The *Jewish Unequal, or Planetary Hours*.

5. The

5. The *Azimuths*, shewing in what quarter of the World; or upon what Point of the *Compass* the *Sun's* on at all times of the Day.

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## C H A P. XXVIII.

*How to describe the Equinoctial, the two Tropicks, and other Parallels of Declination, upon any Sun-Dial.*

**T**HE two *Tropicks*, being the Boundaries of the *Sun's* Course (for he never exceeds those Limits,) therefore it is best, first to shew how they may be described for between them all other *Circles* (either Great or Small) must be Projected, and the manner of describing them upon several Planes various.

### S E C T. I.

*On the direct East, or West, and Equinoctial Dials.*

**L**ET an Example be of direct East Dials in the Latitude of 51 deg. 30 min.

How to describe the Hour-Lines upon these Planes, is shewed in the 4th and 7th Chapters of this Book. Therefore such a Dial being drawn as in Figure 25, through the Foot of the *Perpendicular Stile*, as at E, draw a Line MEN, Parallel to the *Horizon*; for the *Horizontal Line* in all Planes, must be drawn through the Foot of the *Perpendicular Stile*, and also through the Point

Point where the Equinoctial Circle crosseth the Hour-Line of Six. Your Dial, with the Equinoctial Line hereof, HES, being drawn, we come to describe the *Tropicks*.

1. Upon a piece of fine Card-past-board, draw the Line O R, as in *Figure 26*, representing the Equinoctial Line in your Dial; and (because the *Tropicks* are 23 deg. 30 min. distant from the Equinoctial) with 60 deg. of your Line of Chords, upon the Point O, describe an Arch of a Circle, and set upon it 23 deg. 30 min. from R to S, and draw the Line O S, representing the two *Tropicks*; and the Angle S O R, you may call a *Trigon*.

2. Out of your Dial take the length of the *Perpendicular Stile* E G, and set it upon your *Trigon* from O to P, and draw the Line P 6 *Perpendicular* to O R. Also,

|                           |    |                 |   |       |   |    |        |
|---------------------------|----|-----------------|---|-------|---|----|--------|
| Take the distance from G, | 7  | with the Equi-  | q | and   | q | 7  | per-   |
| to the Interse-           | 8  | noctial, and    | r | draw  | r | 8  | pen-   |
| ction of the              | 9  | set it upon the | s | the   | s | 9  | dicu-  |
| Hour Line of              | 10 | Trigon, from    | t | Lines | t | 10 | lar to |
|                           | 11 | O, to           | v |       | v | 11 | O R    |

Thus having prepared the *Trigon*, out of it take the distance P 6, and set it upon the 6 a Clock Hour line, from E to c: Also take the distance q 7, and set it upon your Dial from V to b, and from VII to d: Also take r 8, and set it upon your Dial from IV to a, and from VIII to e; Likewise take the distance s 9, and set it on your Dial from IX to f: Also, take t 10, and



set it on your Dial from X to g; Lastly, take v 11, and set it on your Dial from XI to b.

These Points *a, b, c, d, e, f, g, h*, are the Points through which the *Tropick of Cancer* must be described; therefore if through them a Line be drawn with an even hand making no Angles, that shall be *Tropick of Cancer*.

The *Tropick of Capricorn* may be described in the same manner, for if from your *Trigon* you take

|              |   |    |    |                                |   |      |   |
|--------------|---|----|----|--------------------------------|---|------|---|
| The distance | { | r  | 8  | And set it upon your Dial from | { | VIII | k |
|              | s | 9  | IX |                                |   | l    |   |
|              | t | 10 | X  |                                |   | m    |   |
|              | v | 11 | XI |                                |   | n    |   |

Those shall be the Points through which the *Tropick of Capricorn* must be described; therefore if through *k, l, m, n*, a Line be drawn with an even Hand, it shall be the *Tropick of Capricorn*; And,

|                    |   |            |                |   |           |                                                                            |
|--------------------|---|------------|----------------|---|-----------|----------------------------------------------------------------------------|
| When the Sun is in | { | Capricorn, | which is about | { | Decem. 11 | the Shadow of the top of the Stile will pass along those respective Lines, |
|                    |   | Aries,     |                |   | March, 10 |                                                                            |
|                    |   | Libra, or  |                |   | Sept. 12  |                                                                            |
|                    |   | Cancer,    |                |   | June. 11  |                                                                            |

And according to this Method, may any other intermediate Parallels of *Declination* be inserted; as for Example: Suppose I would insert the Parallels of the Sun's entrance into the 12 Signs, *Aries* and *Libra* are inserted already, also *Cancer* and *Capricorn*; for the rest, as when the Sun enters into

|                     |   |                      |                    |  |
|---------------------|---|----------------------|--------------------|--|
| <i>Taurus,</i>      | { | the Sun hath 11 deg. | } of Declinations. |  |
| <i>Virgo,</i>       |   |                      |                    |  |
| <i>Scorpio,</i>     |   | 30 min.              |                    |  |
| <i>Pisces,</i>      |   |                      |                    |  |
| <i>Gemini,</i>      | { | the Sun hath 20 deg. |                    |  |
| <i>Leo,</i>         |   |                      |                    |  |
| <i>Sagittarius,</i> |   | 12 min.              |                    |  |
| <i>Aquarius</i>     |   |                      |                    |  |

Therefore take 11 deg. 30 min. and 20 deg. 12 min. out of your Line of Chords, and set them upon the Arch RS of your *Trigon*, from R to V and X, and draw the two Lines OV and OX.

These Parallels, being thus put in your *Trigon*, they may be transferr'd into the Dial, in all Respects as the *Tropicks* were; and as you see done in *Fig. 26*.

## SECT. II.

*In a direct South or North Dial.*

*Fig. 27.*

**H**AVING drawn your Dial, as is taught in Chapters 2, 3, or together with the *Stile*, your first work must be to proportion your *Stile* to your Dial; which to do, assume any convenient Point in the *Substile* (here the Line of XII) for the farthestmost *Tropick*, as here the Point ☿; then the *Stile's* height being 38 deg. 30 min. add 23 deg. 30 min. thereto, the Sum is 62 deg. and that is the *Meridian Altitude* of the Sun when he enters *Cancer*, and

the Complement thereof to 90 deg. is 28 deg. Therefore, upon the Point *Cancer*, make an Angle  $B \text{ } \textcircled{S} \text{ } A$ , to contain 28 deg. so shall the Line  $\textcircled{S} \text{ } A$  cut the *Axis* of the Stile  $OA$ , in  $A$ ; then from  $A$  let fall a *Perpendicular* to  $O \text{ } \textcircled{S}$ , as  $AB$ ; and so is your Stile proportioned to your Dial; and the Line  $CBD$  (being drawn Parallel to the *Horizon*, through the Point  $B$ ) shall be the *Horizontal-Line* of your Dial.

This done, prepare a *Trigon*, as *Figure 28*, in which make  $EF$  equal to  $OA$ , and  $FG$  equal to  $OB$ , and  $EG$ , to  $AB$ , the *Triangle*  $EFG$ , in the *Trigon*, equal to the *Triangle* of the Stile  $OAB$ , in the Dial.

From the Point  $E$ , draw a *Perpendicular* to  $EF$ , as  $E \text{ } 12$ , for the *Equinoctial*; and upon  $E$ , with 90 deg. of Chors describe the Arch  $H \text{ } 12 \text{ } L$ , and upon it set 23 deg. 30 min, from  $12$  to  $H$  and  $L$ , and draw the line  $EH$  for the *Tropick* of *Cancer*, and  $EL$  for the *Tropick* of *Capricorn*: Draw the *Substiler Line*  $FG$ , quite through the *Trigon*, crossing the *Equinoctial* in  $a$ , and both the *Tropicks*.

This done, out of your *Trigon* take the distance from  $F$  to  $a$ , and set on your Dial from the Center  $O$  to  $c$ , through which Point draw the Line  $\gamma \text{ } c$  for the *Equinoctial*: Then from  $O$ , the Center of your Dial, take the distance to the Intersection of the *Hour-Line* of 11, or 1 with the *Equinoctial*, and set it on the *Trigon*, from  $F$  to  $b$ : Also take the distance from  $O$ , to the Intersection of the *Hour-line* of 10 or 2, and set it from  $F$  to  $c$ : Likewise take the distance from  $O$ , to the Intersection of the *Hour line* of 9 or

3, and set it from F to d: Lastly, the distance from O, to the Intersection of 8 or 4, with the Equinodial, set from F to e; and draw the Lines, Fa, Fb, Fc, Fd, Fe, through the Trigon, making them 12, 11, 10, 9, 8, and 7, 2, 3, 4, &c. Now to find the Points upon the Dial, through which the Tropicks must pass:

The Distance from F to { 12 } will reach { 50 } on the { 12 }  
                                  { 11 } from O, { Hour } { 11 }  
                                  { 10 } the Center { Lines } { 10 }  
                                  { 9 } of the Dial { of } { 9 }  
                                  { 8 } to { 6 } { 8 }

Through which Points the Tropick of Cancer must be drawn with an even Hand: And,

The Distance from F to { 12 } will reach { vs } upon { 12 }  
                                  { 11 } from O, { 1 } the { 11 }  
                                  { 10 } the Center { Hour } { 10 }  
                                  { 9 } of the Dial { Lines } { 9 }  
                                  { 8 } to { vs } of { 8 }

Through which Points the Tropick of Capricorn must be drawn. And thus you have the Equinoctial, and the two Tropicks, described upon a Direct South Dial.

And as the Tropicks were described on the Dial, so may the Parallel of the same Latitude be described. L 4



constituted by the Sun's motion in the ecliptic  
 and the Earth's motion in the circle of the  
 zodiac. **SECTION III**

*How to describe the Equinoctial, and the two Tropicks, on any Upright Dial Declining, or in such as both Recline and Decline.*

**A**N Example of an Upright Dial declining from the South Westward 30 deg. The making of these Dials is Taught in the fifth and eighth or twenty sixth Chapters of this Book; Therefore having drawn such a Dial, and the Stile and Substile in a due Position, you will find the Height of the Stile to be 23 deg. 37 min. First, make an Horizontal Dial for the Latitude of 32 deg. 37 min. as in the Declining Dial, Fig. 27, where the Substiler-line is taken for the Hour-line of 12, as it is there marked, and the other Pricked-lines, are the Hour-lines of an Horizontal Dial for the Latitude of 32 deg. 37 min. Now, if according to the Directions of the foregoing Sections you make Trigon, and insert the Equinoctial, and Tropicks, and afterwards expunge the obscure Lines of the Horizontal-Dial, the Equinoctial Tropicks, and the Horizontal-line will be the same, as if they had been inserted from the true Hour-lines belonging to the Dial-Plane.

And as the Tropicks were described, so likewise may the Parallel of the Sun's Entrance into the other Signs, be inserted if into your Trigon, you put there Arches of Declinations from the Equinoctial, Namely, 11 deg. 30 min. and

20 deg. 12 min. And so are the Parallels of the Signs put into the Dial, *Fig. 29.*

And in any Dial, also may the Diurnal Arches be described, if you put into the *Trigon* such Declinations, as the Sun hath from the Equinoctial, when the Days is either,

|    |        | [ deg. min. ] |       | So are the<br>Diurnal<br>Arches put<br>into the<br>South Dial<br>represented<br>by the prick-<br>ed Lines<br>there, in |
|----|--------|---------------|-------|------------------------------------------------------------------------------------------------------------------------|
| VS |        |               |       |                                                                                                                        |
| 8  | } or { | 16            | Hours | 23 30                                                                                                                  |
| 9  |        | 15            | long, | 21 40                                                                                                                  |
| 10 |        | 14            | as,   | 16 55                                                                                                                  |
| 11 |        | 13            |       | 11 37                                                                                                                  |
| 12 |        | 12            |       | 5 55                                                                                                                   |
|    |        |               |       | 0 0                                                                                                                    |

*Fig. 27,* and the *Trigon* thereunto belonging is *Fig. 28.*

## C H A P. XXIX.

*How the Hours from the Sun's Rising and Setting, are to be described into all Sorts of Sun-Dials.*

**T**HE Hours from *Sun-rising*, are called the *Babylonish Hours*, for they begin their Day at the Sun's Rising: And the Hours from *Sun-Setting*, are called the *Italian Hours*, for in *Italy* they account their Time from the Setting of the Sun the Day preceding.

The

The manner how to describe the *Hours* (is the same in all Planes, and) is easily performed: And because that upon a full *South*, or *Horizontal Dial*, they will appear most Uniform; I have therefore made choice of a direct *South Dial*, as in Figure 27. to describe them; Your *Dial* being drawn, and the *Equinoctial*  $\gamma \text{ } \overline{\text{v}}$ , the two *Tropicks*  $\odot \odot$ , and  $\text{vs vs}$ , and the *Horizontal-line*, *Sun-Rise* — *Sun-Set*; you must (by the last Chapter) describe two obscure *Parallels* of *Declination*, one when the Day is 8 Hours long, as  $\odot 8 \odot$ , and the other when the Day is Sixteen Hours long, as  $* 16 *$ , the *Equinoctial* being the *Parallel* when the Day is Twelve Hours long.

Being thus far prepared the *Inscription* of these *Hours* will be very easy; for it is plain, that when the Day is but 8 Hours long, that the *Sun* Rises at Eight in the Morning; and the first Line after the *Sun's* Rising is Nine in the Morning; also when the Day is 12 Hours long, the *Sun* Rises at 6 in the Morning, and the first Hour after, is 7 in the Morning; Lastly, when the Day is 16 Hours long, the *Sun* Rises at Four in the Morning, and the next Hour after is Five in the Morning: And all the rest as in this Table. Therefore, a straight Line drawn through the Intersection of these *Hours* Lines, with the *Parallels* of 8, 12 and 16 Hours, shall be the First Hour after the *Sun's* Rising all the Year long.

which are the Babylonish Hours

In like manner, if you would insert the seventh after the Sun's rising: By the Table you see, that the Parallel of viii Hours, for the length of the Day, the seventh hour from Sun-rising is 3 in the Afternoon, therefore observe where the Hour-line of 3 crosseth the Parallel of viii Hours, which is at *a*. Also by the Table you see that in the Parallel of xii Hours, for the length of the Day, the

Length of Days.

|      | Length of Days. |     |      |
|------|-----------------|-----|------|
|      | viii            | xii | xvii |
| i    | 29              | 7   | 5    |
| ii   | 10              | 8   | 6    |
| iii  | 11              | 9   | 7    |
| iv   | 12              | 10  | 8    |
| v    | 1               | 11  | 9    |
| vi   | 2               | 12  | 10   |
| vii  | 3               | 1   | 11   |
| viii | 4               | 2   | 12   |
| ix   | 5               | 3   | 1    |
| x    | 6               | 4   | 2    |
| xi   | 7               | 5   | 3    |

seventh Hour from Sun-rising is 1 in the Afternoon; therefore observe where the Hour-line of 1 crosseth the *Equinoctial*, which is at *b*. Thirdly, By the Table you see, that in the Parallel of xii hours, for the length of the Day, the seventh Hour from the *Sun's Rising* is 11 in the Forenoon; and therefore observe where the Hour-line of xi crosseth the Parallel of xvi Hours for the length of the Day, which at *c*; so shall a right-line drawn through these Points, *a*, *b*, *c*, be the seventh Hour after the *Sun's Rising* throughout the Year: And thus by the help of this Table, you may draw all the Hour-lines from the *Sun's Rising*, as you see them drawn, and numbred as in *Fig. 27*.

In the same manner, as the Hours from the *Sun's Rising* (which are the *Babylonish Hours*) were drawn, may the Hours from the *Sun's Setting* (which



(which are the *Italian Hours*) be drawn: The difference being only in the numbring of them; the hours from *Sun Rising*, being numbred from the *West* end of the *Horizontal-line*, by 1, 2, 3, 4, 5, 6, 7, 8, 9, 10: And the *Hours* from *Sun-Setting*, from the *East* end of the *Horizontal-line* backwards, by 23, 22, 21, 20, 19, 18, 17, 16, 15; as appears in *Figure 27*.

*A Corollary arising from the Work of this Chapter.*

The Hour-lines from *Sun Rising* and *Setting*, being described upon any *Dial*, as is before taught, there will by their correspondent Intersections one with another, be Points produced, through which if Lines be drawn, with an even hand, the same shall be the Parallels, of the length of the Day, and such are pricked Lines in *Fig. 27*, numbred upon the *Meridian-line* of the *Dial*, by 8, 9, 10, 11, 12, 13, 14, 15, 16.

## C H A P. XXX.

*Of the Jewish, or Old Unequal, or Planitary hours, and how they may be described upon any Sun-Dial.*

THE Ancients, account of their Day, was from the *Sun's Rising* in the *Morning*, till it's *Setting* in the *Evening*, which space of time they did divide into Twelve equal Parts, were it long, or short; so that in the Summer, all the Time that the *Sun* hath North-Declination, th; hours  
of

of their Day, was longer than a Common equal Hour; and in the *Winter* when the *Sun* hath *South* Declination the Hour of their Day were shorter than a Common equal Hour; but when the *Sun* is in the Equinoctial, their Hours are equal to our common Hours.

The Inscription of these Hour-lines, into all sorts of *Sun-Dials* is very easie, being much like the Inscription of the *Italian* and *Babylonish* Hours, Taught in the last Chapter.

Having drawn your *Dial*, with Hours, halves, and quarters; and also the *Equinoctial*, the two *Tropicks*, and Horizontal-line; and also the *Parallels* of the length of the Day, as is done in *Figure 28*, which a *South Dial Declining Eastward* 15 deg. you must make choice of two *Parallels* of the length of the Day, which must be both of them be equidistant from the *Equinoctial*, which let be the *Parallels* of 9 *Hours*, and 15 *Hours*, for those two *Parallels* are most convenient for this purpose because the *Jewish Hours*. in those *Parallels* will

| The Jewish. | The Parallels of 15 H. |    | Equinoctial. | The Parallels of 9 H. |    |
|-------------|------------------------|----|--------------|-----------------------|----|
| H.          | H.                     | M. |              | H.                    | M. |
| i           | 5                      | 45 | 7            | 8                     | 15 |
| ii          | 7                      | 00 | 8            | 9                     | 30 |
| iii         | 8                      | 15 | 9            | 9                     | 45 |
| iv          | 9                      | 30 | 10           | 10                    | 00 |
| v           | 10                     | 45 | 11           | 11                    | 15 |
| vi          | 12                     | 00 | 12           | 12                    | 00 |
| vii         | 1                      | 15 | 1            | 0                     | 45 |
| viii        | 2                      | 30 | 2            | 1                     | 30 |
| ix          | 3                      | 45 | 3            | 2                     | 15 |
| x           | 5                      | 00 | 4            | 3                     | 00 |
| xi          | 6                      | 15 | 5            | 3                     | 45 |
| xii         | 7                      | 30 | 6            | 4                     | 30 |

justly

justly fall upon the even *Hours*; halves, or quarter :  
 Now the Points through which the *Jewish* hours  
 are to be drawn, as the Table before will direct;  
 wherein you see, that the first *Jewish* Hour is to  
 be drawn through 5 Hours, 45 min. in the Pa-  
 rallel of 15 Hours, through 7 in the *Equinoctial*;  
 and through 8 Hours and 15 min. in the Parallel  
 of 9 Hours: In like manner the second *Jewish*  
 Hour must be drawn through the intersection of  
 7 Hours, in the Parallel of 15 Hours, through  
 8 in the *Equinoctial*; and through 9 in the paral-  
 lel of 9 Hours: And so must all the rest of them  
 be described as the Tables does direct, and as you  
 see done in *Figure 30*. And in this manner, by  
 the help of this Table, may they be described in  
 all sorts of Planes, whither Direct Reclining, or  
 Declining.

## CHAP. XXXI.

*How the Azimuth must be described, upon any  
 Sun-Dial.*

**T**HE *Azimuths* are great Circles, and be-  
 ing projected upon all Dials, become  
 straight lines; and they are variously described  
 according as the Dial-Plane is situated, Particu-  
 lars of which follow.

SECT.

## S E C T. I.

*On an Horizontal Dial.*

**I**N these Dials the *Azimuths* are most easily described: for, your Dial being drawn, with the *Tropicks* thereon, you have no more to do, then upon the foot of the *perpendicular Stile* as at O (in Figure 31.) as a *Center*, to describe a *Circle*, as  $\odot$ , N $\odot$ , which you may divide into 32 equal points (beginning at N) answering to the 32 points of the *Mariner's Compass*, or else you may divide into 90 equal parts or degrees, noted with \*\*\*, &c, and through those points draw streight Lines from O, the foot of the *perpendicular Stile*, and they shall be the true *Azimuth* upon an Horizontal Dial, which you may denominate by South S, by E, S. S.E, S.E. by S, &c. as you see done in Figure 31.

## S E C T. II.

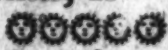
*Upon a Direct East, or West Dial.*

Fig. 251

**H**AVING made an East Dial and therein inserted the *Equinoctial*, and the two *Tropicks*, and the *Horizontal Line*, you may proceed to describe the *Azimuths* in this manner;

Upon the point E, of the *Horizontal Line* of your Dial, MEN, erect the *Perpendicular* E Q, equal to EG (the height of your *Stile* of your Dial)



Dial) and upon Q, as a Center, describe the *Quadrant* QEL, and divide it into eight equal Parts, representing one quarter of the *Mariner's Compass*, and from Q through those Points, draw Lines to the *Horizontal-line* MEN, as  from which Points let fall Perpendiculars from the *Horizontal-line*, and they shall be the *Azimutbs* between the *South* and the *East*; and those Points which fall between the *East* and the *North*, as E. by N. — E. N. E. — N. E. by N. — are the same Distances set upon the *Horizontal-line* from E, towards the Left-hand, as the three *Azimutbs* towards your Right-hand, is ; through which Points, if Lines be drawn perpendicular to the *Horizontal-line*, they shall be the *Azimutbs*, or points of the *Compass* between the *East* and the *North*: As in *Fig. 25*. And as the *East-Dial* contains the *Azimutbs* between the *South* and the *East*: The *West-Dial* must contain those between the *South* and the *West*.

### S E C T. III.

Upon the Direct South Upright Dial. Fig. 27.

THE Dial with the Equinoctial, and the two Tropicks and the *Horizontal-line* described thereon, the *Azimutbs* may be inserted thereon as followeth.

First, Take the length of the perpendicular Stile of your Dial AB, and set it upon the *Meridian* of your Dial from B to G.

Secondly,

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Secondly, With the distance GB, upon G, describe the Circle EBF, which divide into 16 equal Parts (if you will) but I have here divided it but into 8, to shew the manner of the Work, in the Points \*\*\*\*, &c. Through which Points from G, draw obscure Lines extending them till they touch the Horizontal Line of your Dial CBD, now if from these Points of touching you draw Lines perpendicular to the Horizontal-line between the Tropicks, (or Parallels to the Line of 12,) they shall be the *Azimuth* required.

*Note*, I have not drawn the Lines themselves in this Fig. 27. because the Dial is full enough of Lines already.

## S E C T. IV.

*Upon the South Declining Dial. Fig. 30.*

**A**N Example shall be of a *South-Dial*, Declining Eastwards 15 deg.

Such a *Dial*, being drawn, and the *Equinoctial Tropicks*, and the *Horizontal-line* inserted thereon: Upon the Point B of the Horizontal-line erect the Perpendicular BC, equal to BO, the Perpendicular Stile of your Dial; upon which Point C, describe the Semicircle RBS, which done, lay a Ruler to C, and the Point G, where the Hour-line of 12 crosseth the Horizontal-line, and where the Ruler cuts the Semicircle RBS, at that Point begin to divide it into 16 equal parts, at the points \*\*\*, &c. And from the Center C, draw Lines obscurely thro' those points, extending

M

tending them till they touch the *Horizontal line*, DE, in the Points *a b c d e f g h i k* and *l*, through these Points Right-lines being drawn, parallel to the *Meridian*, shall be the *Azimuth* desired, which you must number according to the *Situation* of the *Plane*: Namely, The *Western Azimuths* on the *East* side of the *Meridian*, and the *East Azimuths* on the *West* side of the *Meridian*, as you may see in *Fig. 30*.

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## C H A P. XXXII.

*Of the Meridians of other Countries, and how to insert them into any Sun-Dial.*

**I**T is easy to insert the *Meridian* of any other *Country* into any *Sun-Dial*, made for any other *Place*; if first you know the difference of *Longitude*, between the two *Countries*, in *Time*; and also, whether the *Remote Country* lie *Eastward* or *Westward*, from the *Home Country*: For,

If the *Remote Country* lie *Eastward* of the *Home Country*, it is *Noon* sooner than it is at the *Place* the *Dial* doth stand in; if it lie *Westward*, then it is *Noon* later.

*As for Example,*

Suppose that in a *Sun-Dial* here at *London*, you would insert the *Meridian* or *Noon-side* of *Constantinople* by the best *Geographers*, the *Meridian* of *Constantinople* lies *Eastward* of the *Meridian* of *London*, 30 deg. 45 min. which converted into *Time* by allowing 15 degrees to one hour, and 1 degree

degree to 4 minutes of Time; it is 2 hours and 15 min. that is 2 hours and a quarter. Wherefore if you subtract 2 hours 15 min. from 12 hours, the Remainder will be 9 hours 45 min. or 3 quarters of an hour. Therefore upon a Dial here at London, you write the word *Constantinople*, upon the Hour-line of 9 and 3 quarters, (or make this  $\ast$ ) the Shadow of the Stile of the Dial, when it shall fall upon the Word or Mark, you may conclude it to be Noon at *Constantinople*; and knowing that, it is easily known what hour it is at any Time of the Day.

You have several Countries inserted in the Direct South Dial. Fig. 1.

### C H A P. XXXIII.

*The manner of Cutting divers Bodies in Wood or Stone, and making Dials upon them.*

**T**HERE are seven Bodies usually cut in Stone or Wood; whereof five of them are called Regular Bodies, because they may be inscribed in a Sphere: And they are also called the five regular Platonical Bodies, because Plato was the Inventor of them, and are as followeth, the Cube; the Tetrahedrum, the Octobedrum, the Dodecabedrum, and the Icosahedrum, the others are one of Twelve Rhombs, and the other of Thirty Rhombs: And the Cube is the Mole or Lump, out of which the rest are contrived I shall begin with that first.



*How to cut the Cube.*

[*Definition.*] A *Cube*, is a solid Body comprehended by Six equal Squares, as are A, B, C, D, A, D, E, F, and D, C, F, G. — The cutting of this Body is plain by the Definition; for let every side of every square be equal, as A, B, to D, F, A, E, to C, G, &c. and you will make a *Cube* of what greatness you will, this Body is capable of five ordinary *Dials*, the first square being the Base to stand upon: wherefore if you set the side A, D, E, F, *South*, then will the side opposite thereto be *North*, D, C, F, G, *East*, and the side opposite will be *East*, and A, B, C, D, *Horizontal*, all which *Dials* are made in the former part of this Book: But if you place any of the Angles of the Horizontal Squares *South*, then will every side decline 45 deg. for if you turn the Angle D, *South* then will the *Diagonal Line* A, C, be *East* and *West*, and the side C, D, F, G, will be a *South Declination*, *East* 45 deg. and his opposite a *North* declining *West* 45 deg. and A, D, F, E, is a *South* decl. 45 deg. *West*, and his opposite a *North* declining 45 *East*, all which *Dials* are made by the Direction in this Book.

*How to cut the Tetrahedrum.*

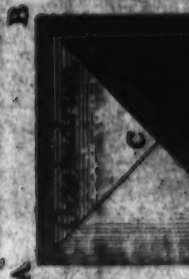
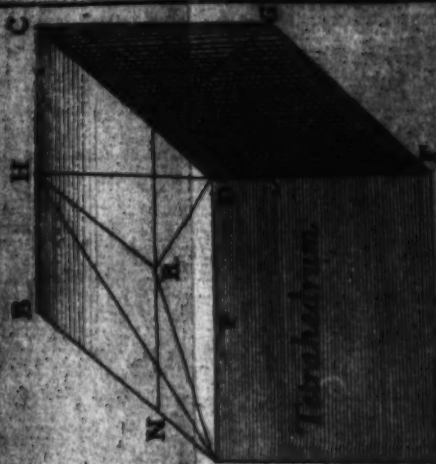
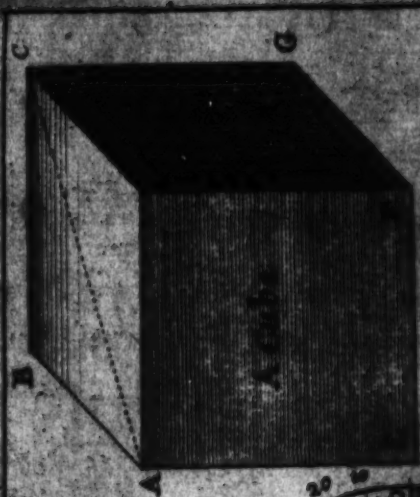
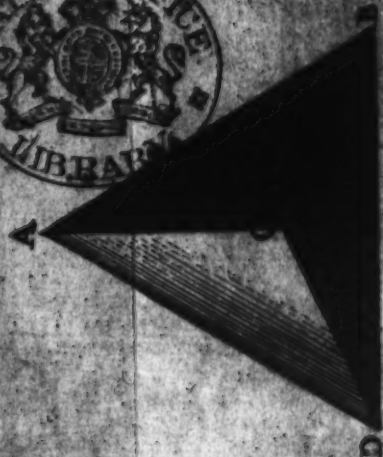
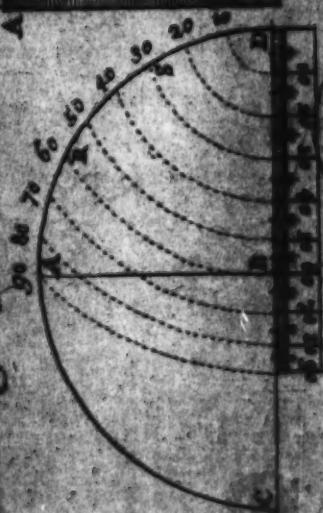
[*Definition.*] The *Tetrahedrum*, is a solid Body comprehended by four *Equilateral Triangles*, as ACB, ACD, and DCB.

To cut this Body, you must make a *Parallel-pipe*.



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*piped.* Let the Breadth AD, be 10000, and the Height AE, be 8164, and the length AB, be 8660, upon the upper Face and Base thereof draw to opposite *Equilateral Triangles*, as ADH, divide the *Perpendicular* PH, into three Parts, and set one part thereof which is equal to 2886, from A to N, and from D to L, draw the Line NL, and in the middle of the point R, will be the Vertex of the Solid ABD; From the Point L to the Angles F and G, draw to streight Lines LF, and LG; do the like on the opposite side by the point N; cut off the two *Triangular Portions* L, D, E, N, A, E, and G, L, C, N, B, so will there remain the solid Body called a *Prisma*, whose two sides FLG, and the Opposite, are equal *Triangles*, the other three sides L, F, N, E, &c. are *Parallelograms*. Next by the Points F, K, H, and the side of the *Triangle* FH, drawn in the Base; as also by the Points EKH, and the other side of the *Triangle* EH, cut this *Prisma*, and there come forth the Solid Body A, C, D, B, the *Tetrahedrum* desired. The Body thus prepared set the Angle A *South*, then will the side BOD, be the *North* Reclining 19. 28 and the other two sides AOB, and AOD, will be *South* Decliners 60 deg. and will recline as the former. The making of these Dials is Taught in the former Part of this Book. The *Requisites* and *Hour Distances* are as followeth.

| North Recl. 19.<br>28. the Comple-<br>ment of. the Lat. from the<br>add 38.28. The Substile.<br>St. heig. 57.56. |                              |    | Hours<br>from the<br>Substile. | True<br>Hour di-<br>stances. | Hours<br>from the<br>Substile. |
|------------------------------------------------------------------------------------------------------------------|------------------------------|----|--------------------------------|------------------------------|--------------------------------|
| Direct North Re-<br>clining.                                                                                     |                              |    | South-<br>Declin.              | Reclin.                      |                                |
| Hours<br>from the<br>Meridi-<br>an.                                                                              |                              |    | D.                             | M.                           |                                |
|                                                                                                                  | True<br>Hour di-<br>stances. |    | 3                              | 19                           | 36                             |
|                                                                                                                  |                              |    | 4                              | 04                           | 00                             |
|                                                                                                                  |                              |    | 5                              | 02                           | 13                             |
|                                                                                                                  |                              |    | 6                              | 01                           | 11                             |
|                                                                                                                  |                              |    | 7                              | 00                           | 41                             |
|                                                                                                                  |                              |    | 8                              | 00                           | 10                             |
|                                                                                                                  |                              |    | Substile.                      |                              | Substile.                      |
| 12                                                                                                               | 00                           | 00 | 9                              | 00                           | 19                             |
| 11                                                                                                               | 1                            | 12 | 10                             | 00                           | 52                             |
| 10                                                                                                               | 2                            | 27 | 11                             | 01                           | 32                             |
| 9                                                                                                                | 3                            | 40 | 12                             | 00                           | 37                             |
| 8                                                                                                                | 4                            | 55 | 1                              | 00                           | 00                             |
| 7                                                                                                                | 5                            | 72 | 2                              | 19                           | 26                             |

The other two *South* Reclining Declining have the same *Dials* serving for both; changing but the Position of the Substile and Hours as hath been directed. The Requisites of the foregoing Table of *South* Declining Reclining are as followeth.

|                                       |       |       |
|---------------------------------------|-------|-------|
| The Planes Reclination                | — — — | 19 28 |
| The Planes Declination East or West,  |       | 60 00 |
| The distance of the Mer. and Horizon, |       | 60 00 |
| The Stiles Height above the Plane.    |       | 01 50 |
|                                       |       | The   |

The *Substile* distance from the *Meridian* — 02 36  
 The *Planes* Longitude — — — 134 46  
 Therefore the *Substile* falleth between 8 and 9 of  
 the Clock in the *East-Dial*, and between 3 and  
 4 in the *West*.

The best way of making these two *Dials* will  
 be by the *Polar Scales* as you did the *far De-*  
*cliners*.

### How to cut the *Octohedrum*.

An *Octohedrum* is a solid Body, comprehended  
 of eight equal *Equilateral Triangles*, as are *ACB*,  
*ACD*, *BCE*, and *ECD*; To cut this Body  
 you must take a *Parallel piped* *BEFC*, let  
 the breadth thereof *BC*, or *AD*, be 10000,  
 and the height thereof *AE*, or *CG*, be 8164, and  
 the length thereof *BA*, or *FG*, be 11547, let *AI*,  
 and *DK*, and *LC*, be 2887, one fourth (or a  
 quarter) of *AB*, or *FG*, by which draw the Line  
*IK*, upon the Superficies, and the like by *L*, in  
 the Base, make equilateral *Triangles IKN* upon  
 the Superficies, and from the Point *L* in the Base  
 the like, so that the Point *N* of the Triangle in  
 the Base may be opposite to the Point *H*, of the  
 Superficies; draw the Lines *KF*, *KL*, and *LC*,  
 on the one side of the Figure, and the like on the  
 other side, cut off the *Triangular* portion *IKFE*,  
 downwards, and the opposite to it *LGCB*, up-  
 wards, and there will remain two equal Oblongs  
*KIBHC*, and *LFNE*, the Base inclining from  
 the Line *BHC*, as much as the Superficies doth  
 recline from the Perpendicular of *NEF*, next cut



off the Portions LKH, and IH, above, LKN and IN, by the *Triangle* beneath, so shall you have at six cuts the solid of eight equilateral *Triangles* ABCDE, desired. The Body thus prepared, and the same Dials of the *Tetrahedrum*, will serve for the *Ostobedrum* also; for the Plane BCE, will be a *South* Incliner, and his opposite a *North* Reclining 19. 28, and the Plane DAC, and ECB, will decline 60 deg. and recline as the other, and their opposites Declines and Inclines, 60 deg. as may be seen by Bodies themselves, joyning to the Reclining side, BCD, of the *Tetrahedrum* to the Inclining side DCE, of the *Ostobedrum*, will plainly demonstrate the same, the Dials being the one and the same in both, there will not be any need to reiterate the Work over again.

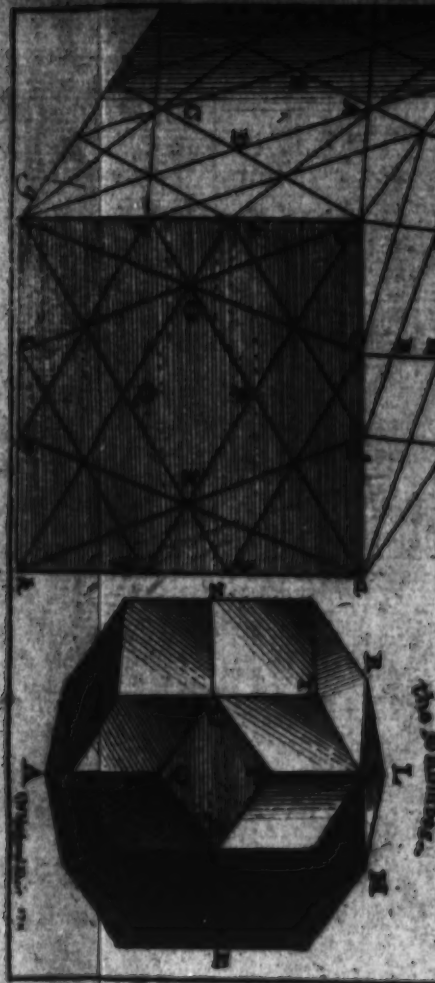
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How to cut the

## DODECAHEDRUM.

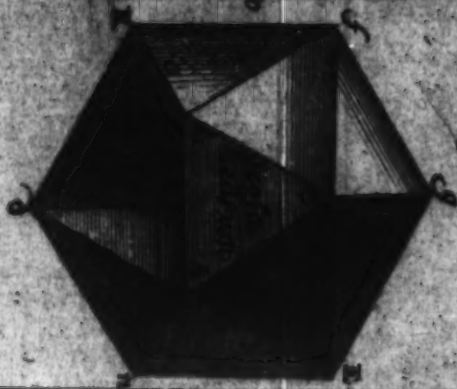
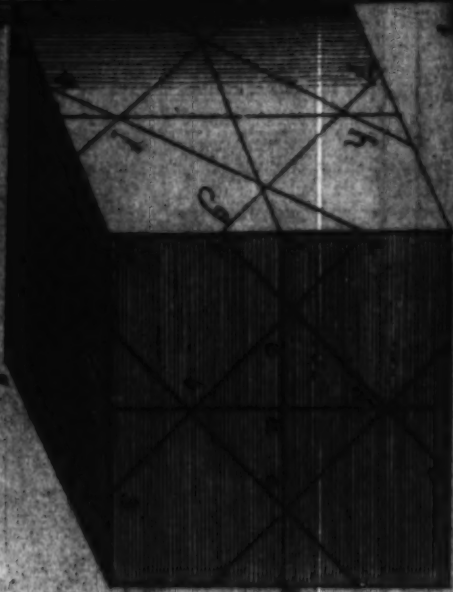
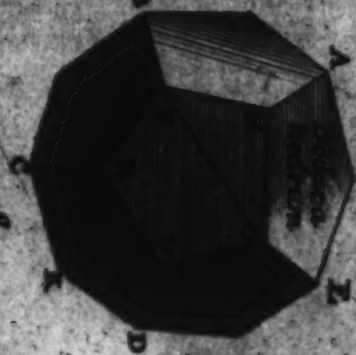
THE *Dodecabedrum* is a solid Body, comprehended of 12 equilateral Pentangles, as HSRVO, HSBA, and HOES, &c. To cut this Body, you must first make a Cube; as is PRSV, divide each side into halves, as P e at, a. b. R. S, at f. o, and X. P. as C, D, let each half P. a, X. o, and R. f, be the *Radius*, or 10000 divided by extream and mean Proportion P. g, X. n, and V. o, shall be 6180, the great-





6-1/586

Fig. 141



que se romba.





er Segment, and  $g, c$ , and  $n, b$ , be 3820, the lesser Segment, and so must the rest of the sides be also divided, but with this Caution, that the middles and segments of every side Conterminous be drawn cross to others, as those of  $P, q$ ,  $R, X$ , cross those of  $X, R$ , and  $S, V$ , and they again cross to them of  $P, X$ , and  $V, Z$ , yet every opposite side Parallel to each other, from the quarter Segment of the one side, to the middle Line of the other, draw streight Lines cross the Body, as are  $n, C, K, o$ , and  $o, b$ ; cut off each Triangular *Prisma*, viz.  $n, o, D, C, L, K, f, o$ , and  $m, o, b, a$ ; and so of the rest. And so shall you at twelve Cuts, frame the *Dodecabedrum*, consisting of twelve *Pentangles*, as is represented by the Figure: The Body being thus prepared, set the Angle  $H$ , of the Horizontal Plane  $HRS, VO$ , South, then shall the five superior Planes recline, and their Opposites incline as much, viz.  $RVDKC$ , will be a direct North reclining 26 deg. 33 min and  $VODE$ , and  $RSBC$ , two North reclining as much, and declining also 72 deg.  $HOEA$ , and  $HSBA$ , two South reclining as much, and declining 36, the Reclination of the five Planes being the same.

Having the Reclination of the direct North Dial, it is to be made as you have been Taught in the foregoing Chapters, whose hour distances, for all the Planes are as followeth.

Direct

| North Reclining |               |       | South Reclining |       |               |
|-----------------|---------------|-------|-----------------|-------|---------------|
| Declining 92 00 |               |       | Declining 36 00 |       |               |
| Hours           | on the Plane. | Hours | on the Plane.   | Hours | on the Plane. |
| 12              | 82            | 05    | 04              | 08    | 71            |
| 1               | 81            | 56    | 22              | 05    | 07            |
| 2               | 10            | 37    | 35              | 05    | 06            |
| 3               | 9             | 24    | 18              | 27    | 04            |
| 4               | 8             | 14    | 12              | 08    | 04            |
| 5               | 7             | 05    | 09              | 09    | 03            |
| 6               | 6             | 02    | 10              | 10    | 02            |
| 7               | 5             | 10    | 17              | 11    | 01            |
| 8               | 4             | 19    | 38              | 12    | 03            |
| 9               | 3             | 31    | 07              | 01    | 11            |
| 10              | 2             | 47    | 09              | 02    | 10            |
| 11              | 1             | 69    | 51              | 03    | 09            |

*Note, The North Recliners and their Opposite declining 72 deg. have the same Dials serving for all four, changing the Position of the Style and Hours, as before was directed; and are to be made by the Rules of the foregoing Chapters. The Requisites for both the reclining declining Dials are as followeth.*

First, For the North Dial declining 72 deg.

|                                      |       |
|--------------------------------------|-------|
| North Reclining                      | 26 23 |
| Declining East and West              | 72 00 |
| The distance of Meridian and Horizon | 36 00 |
| The                                  |       |

The Subst. distance from the Mer. — 82. 04

The Plane's difference of Longitude — 85. 50

The Stile height — 31. 28

Secondly, The Requisite for the South

declining 36 deg. — 26. 33

South Redlining — 26. 33

Declining East and West — 36. 00

The Distance of the Mer. and Hor. — 72. 00

The Substiles distance from the Meridian — 03. 33

The Planes Difference of Longitude — 32. 33

The Height of the Stile — 05. 44

How to CUT

The ICOSAHEDRUM.

THE *Icosahedrum* is a Solid, comprehended of

twenty equal Equilateral Triangles, as are

A, b, c, A, b, d, A, E, c, c, d, f, &c. There

are two ways to cut this Body; the one is the

very same as the *Dodecahedrum* was cut, drawing

the Parallel Lines upon the Cube, at the distance

of the lesser Segment, as there you drew them

from the greater Segment.

The other way is thus; divide each side of the

Cube *g, q, r, X*, into half, and draw straight

Lines crossing at right Angles, as *b, d, e, v, b, v,*

and *f, g, and k, m, and l, n*; then making *p, o,*

or *o, q*, half the side, the Radius 10000, let *a, e,*

the greater Segment 6180, be set from *a*, upon

each middle Line to cross *b, c, d, e, and b, g, f, h,*

by each two Points, viz. *b, e, c, d, and f, b, and*

*l, g,*



*L, g, &c.* draw streight Lines crossing each other at right Angles round about the Cube, so shall you have eight *Equilateral* Triangles, such as are 2, 3, 4, and 5, 6, 7, &c. by which every corner being cut off, their will remain six Squares, as *b, c, d, e, g, h, f, i, k, l, m, n*, and eight Sex-angles; then shall *b, d*, be the Base, and the Point *g*, of the next Square the Vertex to cut out the Triangle *b, d, g*, and *g, i*, shall be the Base, and *K*, the Vertex to cut out the Triangle *g, i, k*, and *K* in the Base and *b*, the Vertex to cut out *K, m, b* and these three being cut, will leave a fourth Triangle between them *K, b, g*; and so of the rest till you find the Body come forth.

The Body being thus prepared, let the Angle *C*, of the *Horizontal A, b, C*, South, then shall *A, b, d*, be a direct North Reclining 48 deg. 11 min. and the opposite Inclining as much, *A, C, E*, and *C, b, f*, are two South Reclining as much, but Declining 60 deg. The other six *Contiguous* with the three do all Recline alike 19 28, whereof the two South *g, C, E*, and *g, c, f*, do also Decline 22 14, the two backward Northern Planes *K, h, d*, and *n, A, d*, do decline 37 deg. 45 min. and the two intermediate North Planes *b, K, f*, and *A, n, E*, do also decline 82 14, and as these do, so doth their opposites decline, and recline as much. These Things being considered, and the Body being prepared, the North reclining Dial 48 deg. 11 min. is made according to the foregoing Chapters.

Here followeth a Table of all the Hour distances of all the Planes belonging to this Body, with the Requisites of the Reclining declining Planes.

North

| North Reclining 48 11 |                |       | South Reclining 48 11 |       |                    | South Reclining 22 14 |                    |       |
|-----------------------|----------------|-------|-----------------------|-------|--------------------|-----------------------|--------------------|-------|
| Stiles height         |                |       | Declining             |       |                    | Declining             |                    |       |
| 86 39                 |                |       | 60 00                 |       |                    | 22 14                 |                    |       |
| Hours                 | Hour distances | Hours | Hours on the Plane    | Hours | Hours on the Plane | Hours                 | Hours on the Plane | Hours |
| 12                    | 0              | 05    | 4 7 68                | 13 5  | 8 66               | 58                    |                    |       |
| 11                    | 1 14           | 59 6  | 6 40                  | 48 6  | 7 35               | 8                     |                    |       |
| 10                    | 2 29           | 57 7  | 5 25                  | 17 7  | 6 20               | 37                    |                    |       |
| 9                     | 3 44           | 57 8  | 4 15                  | 32 8  | 5 12               | 30                    |                    |       |
| 8                     | 4 59           | 57 9  | 3 08                  | 25 9  | 4 6                | 53                    |                    |       |
| 7                     | 5 74           | 59    | 2 02                  | 26 10 | 3 2                | 19                    |                    |       |
| 6                     | 6 90           | 00    | Sub.                  | file. | Sub.               | file.                 |                    |       |
|                       |                |       | 10 2 03               | 14 11 | 1 1                | 56                    |                    |       |
|                       |                |       | 11 1 09               | 19 12 | 12 6               | 27                    |                    |       |
|                       |                |       | 12 12 16              | 42 1  | 11 11              | 55                    |                    |       |
|                       |                |       | 1 11 27               | 00 2  | 10 19              | 44                    |                    |       |
|                       |                |       | 2 10 43               | 45 3  | 9 33               | 22                    |                    |       |
|                       |                |       | 3 9 73                | 16 4  | 8 63               | 1                     |                    |       |

North Reclining 19 28      North Reclining 19 28  
Declining 82 14      Declining 37 54

| Hours | Hour di. | Hours | Hour di. |
|-------|----------|-------|----------|
| 12    | 71 17    | 2     | 10 58 44 |
| 11    | 1 40 42  | 1     | 11 56 44 |
| 10    | 2 24 38  | 12    | 12 48 2  |
| 9     | 3 15 6   | 11    | 1 33 2   |
| 8     | 4 8 23   | 10    | 2 20 22  |
| 7     | 5 2 53   | 9     | 3 8 41   |
| Sub.  | file.    | Sub.  | file.    |
| 6     | 6 2 15   | 8     | 4 2 14   |
| 5     | 7 7 40   | 7     | 5 13 19  |
| 4     | 8 14 10  | 6     | 6 25 17  |
| 3     | 9 23 13  | 5     | 7 38 56  |
| 2     | 10 38 8  | 4     | 8 55 00  |
| 1     | 11 56 26 | 3     | 9 73 46  |

The other two *South* recline as much, and decline also 60 deg. viz. *b, e f*, and *A, C, E*, have the same *Dials* serving for both, changing the Position of the *Substile*, and *Hours* as afore directed;

The *Requisites* for this *Plane* are as followeth;

|                                                            |   |   |    |    |
|------------------------------------------------------------|---|---|----|----|
| The <i>Plane's</i> Declination is                          | — | — | 48 | 11 |
| The Declination <i>East</i> and <i>West</i>                | — | — | 60 | 00 |
| The <i>Dist.</i> of the <i>Meridian</i> and <i>Horizon</i> |   |   | 37 | 45 |
| The <i>Substiles</i> distance from the <i>Meridian</i>     |   |   | 16 | 41 |
| The <i>Plane's</i> Longitude                               | — | — | 38 | 32 |
| The <i>Stiles</i> height                                   | — | — | 22 | 06 |

This *Dial* is to be made by the Rules of the  
XVth Chapter.

The *Requisites* of two *South* reclining 19 28  
viz. *g, C, f*, and *g, C, E*, do also decline 22 14  
and are to be made by the Rules of the XIIth  
Chapter.

|                                                              |   |   |    |    |
|--------------------------------------------------------------|---|---|----|----|
| <i>g, f, C</i> , and <i>g, E, C</i> , <i>South</i> Reclining | — | — | 19 | 28 |
| Declining <i>East</i> and <i>West</i>                        | — | — | 22 | 14 |
| The distance of the <i>Meridian</i> and <i>Horizon</i>       |   |   | 82 | 14 |
| The <i>Substiles</i> distance from the <i>Meridian</i>       |   |   | 06 | 26 |
| The <i>Plane's</i> Longitude                                 | — | — | 21 | 49 |
| The <i>Stiles</i> height                                     | — | — | 16 | 22 |

The *Requisites* of the two middle *Planes*,  
*North* reclining as much, and do also decline  
82 14, and are to be made by the Rules of the  
XVIIIth Chapter.

|                                                        |   |   |    |    |
|--------------------------------------------------------|---|---|----|----|
| A <i>North</i> reclining                               | — | — | 19 | 28 |
| Declining <i>East</i> and <i>West</i>                  | — | — | 82 | 14 |
| The distance of the <i>Meridian</i> and <i>Horizon</i> |   |   | 22 | 14 |
| The <i>Substiles</i> distance from the <i>Meridian</i> |   |   | 71 | 17 |
| The                                                    |   |   |    |    |

|                       |       |       |
|-----------------------|-------|-------|
| The Plane's Longitude | — — — | 83 29 |
| The Stiles height     | — — — | 19 53 |

The Requisites of the other two *North* reclin-  
ers as much, and do decline 37, 54. and are to  
be made by the Rule of the *XVth Chapter*.

|                                                        |       |       |
|--------------------------------------------------------|-------|-------|
| A <i>North</i> Reclining                               | — — — | 19 28 |
| Declining <i>East</i> and <i>West</i>                  | — — — | 37 54 |
| The distance of the <i>Meridian</i> and <i>Horizon</i> |       | 75 31 |
| The <i>SubStiles</i> distance from the <i>Meridian</i> |       | 48 02 |
| The Plan's Longitude                                   | — — — | 56 49 |
| The Stiles height                                      | — — — | 56 54 |

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### How to CUT

## *The Body of twelve Rhombs.*

THE thirty first definition of *Euclid* defineth  
a *Rhomb*, to be a Parallelogram, or a Fi-  
gure consisting of four equal sides, but hath un-  
equal Angles, as out of the Figure *a, b, c, d*, of  
this Plane may be composed two Bodies, one  
consisting of twelve *Rhombs*, as the Figure *a, b,*  
*c, k, b, n, d*, and the other of thirty *Rhombs*. To  
cut the Body of twelve *Rhombs*, make 1 Parall-  
elipped, as is *a, b, g, f*; let the length be 10000,  
as *a, b*, or *c, g*, the breadth and depth, as *f, b*,  
and *f, g*, be 7071, divide the Length into two  
equal parts, as *d, L, i*. from those Points draw  
Lines to the Angles, and they shall include four  
*Rhombs*, as are *m. i. b. L*, and *L, p, d, R*, &c. Draw  
upon



upon each end two Diagonal Lines, as *A, C*, and *B, e*, which joyning at each Angle with the Lines drawn from the middle Point, shall make Triangle such as *A, L, C*, &c. Cut away each Corner by these Triangles, viz. *e*, by the Triangle *A, L, C*; and so of the rest, so shall you at eight Cuts frame the Body of twelve Rhombs, as you see the Figure is.

The Body being prepared, set the Angle *e*, of the Horizontal Rhombs *a, b, c, d*, South, then will *f, h, g, o*, be a direct South, and his opposite a direct North Dial; the other are all declining alike; whereof the four uppermost do recline 30 deg. and opposites do incline as much; and each doth decline 54 deg. 44 min. East and West; therefore any two Dials being made, will serve for all the rest, except the North; South, and Horizontal.

*b, a*, and *a, d*, are North reclining 30 deg. and decline 54 44, and are made by the Rules of the XVth Chapter.

The distance of the Meridian and Horizon 54 44

The Substiles distance from the Meridian 80 47

The Stiles height 44 37

The Plane's Longitude 83 30

The other two Planes as *b, c, f, e*, and *d, e, g, m*, are South reclining 30 deg. and declining East and West 54 44. and are made by the Rules of the XVIth Chapter.

The distance of the Meridian from the Hor. 54 44

The Substiles distance from the Meridian 04 37

The Stiles height 04 36

The Planes Longitude 45 11

North

| North Reclining |       |           | South Reclining |       |           |
|-----------------|-------|-----------|-----------------|-------|-----------|
| 30              |       |           | 30              |       |           |
| Hours.          | Hours | distance. | Hours.          | Hours | distance. |
| 12              | 80    | 48        | 2               | 10    | 32 04     |
| 11              | 160   | 44        | 1               | 11    | 11 05     |
| 10              | 243   | 31        | 12              | 12    | 06 01     |
| 9               | 329   | 12        | 11              | 103   | 33        |
| 8               | 416   | 59        | 10              | 201   | 55        |
| 7               | 506   | 00        | 9               | 300   | 37        |
| Sub-            | file. |           | Sub-            | file. |           |
| 6               | 604   | 34        | 8               | 401   | 13        |
| 5               | 715   | 27        | 7               | 502   | 38        |
| 4               | 827   | 28        | 6               | 604   | 34        |
| 3               | 941   | 26        | 5               | 707   | 52        |
| 2               | 1058  | 14        | 4               | 816   | 31        |
| 1               | 1177  | 59        | 3               | 927   | 43        |

To CUT the

*Body composed of 30 Rhombs.*

THIS Body is represented by the Figure L. Z. A. E. and is somewhat more troublesome to cut than the former, and is framed out of a Cube as a mg & dividing every side by extream and

N

mean

mean Proportion, which is thus easily done; Let  $ab, bg, gm, \&c.$  be 1000, then shall  $ad, bd, bn, mb, bf, gr, \&c.$  be 6180, the greater Segment, which taken of a Sector opened to the widest of any one side, and set from each Angle  $ab, gm, \&c.$  both ways, shall leave  $ad, bc, bb, mn, be, gf, \&c.$  3810, the lesser Segment of the same sides, from the Terms of the greater Segment on the one side, to the lesser on the other side, draw Parallel Lines, as  $de, af, bg,$  and  $gi$ , cross them with the like parallel Lines as are  $ch, bi, ek,$  and  $fp$ , from each opposite Angle  $b, k,$  and  $ag$ , unto the lesser Segment opposite to the said Angles, draw Parallel Lines, as are  $ap, gr, bq,$  and  $kd$ ; so shall you have the Lines on this side the Cube necessary for Direction in cutting this Body; and thus must you do with all the rest of the sides: The Line being drawn as you see in the Figure, there is three Triangles framed about every solid Angle, as are the Lines  $afb, mde,$  and  $gnc$ , about the Angle  $b$ , by which the Angle must be three Times cut, continuing each Line as a part is cut away, to avoid Confusion, so shall you at 24 Cuts produce the Body of 30 Rhombs desired; which being prepared, set the acute Angle  $N$ , of the Horizontal Rhombs  $MNRL$ , South, then shall the Rhomb  $OPQK$ , be a direct South Dial, and his opposite a North,  $ABCD$ , of the Cube (being the same in the Body) West, and his opposite an East Plane; the rest are all South and North declining and reclining, as are the three Rhombs  $OPNT, TNRX,$  and  $TXZO$ , which are conterminous with the Horizontal, and South, and West Planes, do decline

cline and recline, so do all the rest, as from the very Inspection of the Figure of the Body doth sufficiently appear: Wherefore having found the Declination and Reclination of these 3 Planes, there is as much done as is usefull for the Body; then will you find that OPNT, and KPNC, will be two reclining 30 deg. and declining *East* or *West* 20 deg. 54 min. and TNRX, and GMND, will be *South* Reclining 54 deg. and declining 56 deg. 16 min. and OTXZ, and KCDE, *South* Reclining 18 deg. and declining *East* and *West* 58:16, the three *North* ones will be the same with the *South* in all Respects, both for reblination and declination; by which means you may have twenty-four reclining declining *Dials*, whereof three will be *South* reclining declining *East*, and three will have the same declination *West*, and will decline the same, and so there will be of the *North* reclining declining *Dials*, and each hath his opposite, which recline, and decline as much, and there will be five ordinary *Dials*, viz. a *Horizontal*, a *South*, a *North*, an *East*, and *West*, so will you have twenty-nine *Dials* on this Body. The Manner of making these *Dials* is shewed in the foregoing Chapter. The Requisites and hour *Arches* on their Planes are as followeth.

7 18 -

but the 2nd 18 hands between 10 and 11 in the East Dial, and between 1 and 2 in the West Dial. And make by the Rule of the 12th

N 2

South

22 40  
Decl.

South Reclining



| South Reclining |                 | South Reclining |                 | South Reclining |                 |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 30 00           |                 | 54 00.          |                 | 18 00.          |                 |
| Decli. 20 54.   |                 | Declin. 56 18.  |                 | Declin. 58 16.  |                 |
| Hours.          | Hours distance. | Hours.          | Hours distance. | Hours.          | Hours distance. |
| 5               | 764             | 24              | 881             | 17              | 923             |
| 6               | 18              | 25              | 752             | 14              | 88              |
| 7               | 59              | 26              | 633             | 9               | 74              |
| 8               | 45              | 27              | 521             | 4               | 6               |
| 9               | 33              | 28              | 412             | 13              | 5               |
| 10              | 21              | 29              | 304             | 8               | 4               |
| Sub.            | file.           | Sub.            | file.           | Sub.            | file.           |
| 11              | 10              | 30              | 210             | 3               | 30              |
| 12              | 2               | 31              | 180             | 2               | 18              |
| 1               | 114             | 32              | 160             | 1               | 13              |
| 2               | 107             | 33              | 140             | 12              | 5               |
| 3               | 912             | 34              | 120             | 11              | 10              |
| 4               | 827             | 35              | 100             | 10              | 34              |

South Reclining 30 00

Declining East and West 20 54

The distance of the Meridian and Horizon 79 11

The Subfiles distance from the Meridian 02 5

The Stiles height— 06 25

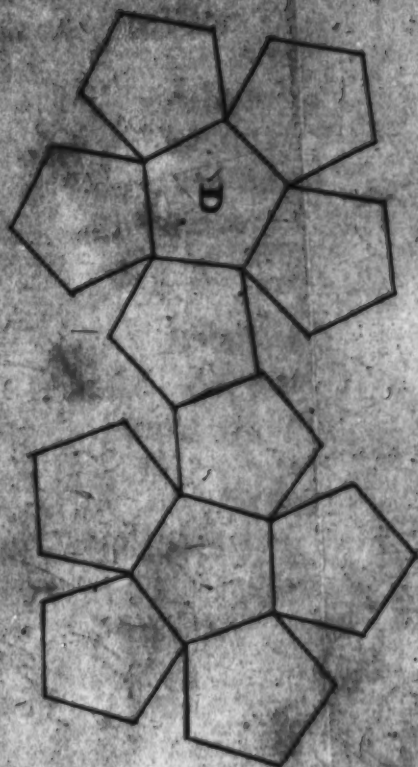
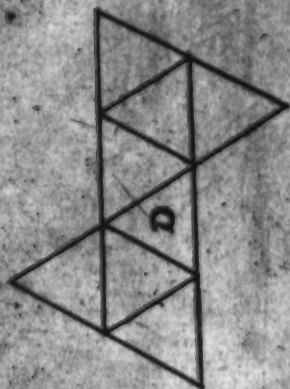
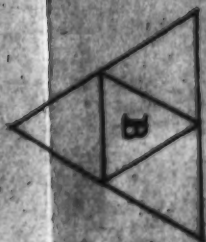
The Planes Longitude 18 7

Therefore the Subfile stands between 10 and 11 in the East-Dial, and between 1 and 2 in the West Dial. And made by the Rules of the 12th Chapter.

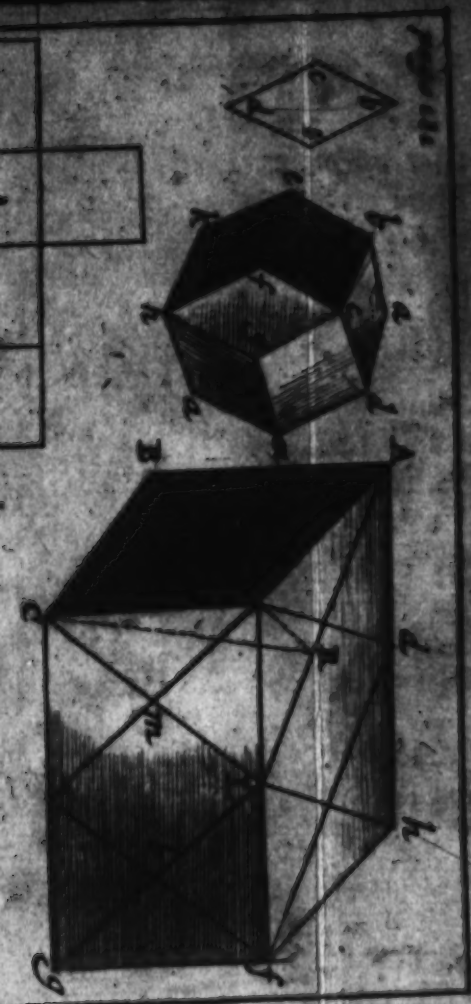
South Reclining — — — — 54 00

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*Declining East and West* 26 16

The distance of the Meridian and Horizon 37 21

The Subfiles distance from the Meridian 16 29

The Stiles height 26 10

The Planes Longitude 33 51

By which means the Subfile falls between 9, and 10, in the *East*, and between 2 and 3 in the *West* Recliner. And made by the Rules of the XV. Chapter.

*South Reclining* 18 00

*Declining East and West* 58 16

The distance of the Meridian and Horizon 63 26

The Subfiles distance from the Meridian 05 28

The Stiles height 03 57

The Planes Longitude 54 11

By which means the Subfile will fall between 8 and 9, in the *East*, and between 3 and 4, in the *West* Decliner. And made by the Rules of the 12th Chapter.

*The Cutting of the five Regular Bodies in Past Board.*

1. **T**HE Cube is composed of six Geometrical Squares, as A.

2. The *Tetrahedrum* is composed of three Equilateral Triangles, as B.

3. The *Octobedrum* is composed of six Equilateral Triangles, as C.

4. The *Dodekahedrum* is composed of twelve Equilateral Pentagons, whose sides are equal, and the Angles 72 deg. as D.

5. The *Icosahedrum* is composed of twenty Equilateral Triangles, as E.

These Bodies being so cut will fold up, and appear as the solid Bodies.

*North*

| North Reclin. | North Reclin. | North Reclin. | North Reclin. | North Reclin. | North Reclin. |
|---------------|---------------|---------------|---------------|---------------|---------------|
| ing 30 00     | ing 30 00     | ing 30 00     | ing 30 00     | ing 30 00     | ing 30 00     |
| Declin. 20 54 | Declin. 58 26 | Declin. 58 26 | Declin. 58 26 | Declin. 58 26 | Declin. 58 26 |
| Hours         | Hours         | Hours         | Hours         | Hours         | Hours         |
| distan.       | distan.       | distan.       | distan.       | distan.       | distan.       |
| 4 8 74 40 2   | 10 87 51      | 11 87 54      |               |               |               |
| 5 7 58 27 3   | 9 69 12 2     | 10 62 20      |               |               |               |
| 6 4 42 24     | 8 52 27 2     | 9 42 26       |               |               |               |
| 7 5 28 29 5   | 7 37 12 4     | 8 27 58       |               |               |               |
| 8 4 14 35     | 6 23 20 5     | 7 16 56       |               |               |               |
| 9 3 1 57      | 5 10 27 6     | 6 7 45        |               |               |               |
| Sub. file.    | Sub. file.    | Sub. file.    |               |               |               |
| 10 2 12 23 8  | 4 1 59 7      | 5 0 39        |               |               |               |
| 11 1 26 11 9  | 3 14 31 8     | 4 9 6         |               |               |               |
| 12 40 37 10   | 2 26 46 9     | 4 18 20       |               |               |               |
| 1 11 55 53 11 | 1 41 56 10    | 2 29 56       |               |               |               |
| 2 10 72 00 12 | 57 40 11      | 1 45 8        |               |               |               |
| 3 09 88 38 1  | 11 74 52      | 12 66 59      |               |               |               |

North Reclining

Declining East and West

The distance of the Meridian and Horizon 79 14

The Subfiles distance from the Meridian 40 36

The Stiles Height 63 28

The Planes Longitude 43 47

This Dial is made by the Rules of the 16th Chapter.

The North Reclining 54 00

Declining East and West 58 16

The distance of the Meridian and Horizon 37 22

The

The *Sun's* distance from the *Meridian* 179 24

The *Stiles* height 54 13

The *Planes* Longitude 61 24

This Dial is made by the Rules of the XVIII.

*Chapter* 101 12 2 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000

The *North* Reclining 18 30

Declining *East* *West* 16 16

The distance of the *Meridian* and *Horizon* 61 26

The *Sun's* distance from the *Meridian* 61 26

The *Stiles* Height 34 34

The *Planes* Longitude 11 11

This Dial is made by the Rules of the XVI.

*Chapter* 101 12 2 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000

And thus you have all the Tables and Requ-

ires belonging to all the Bodies mentioned in

this Book. Note, That upon all *South* reclining

declining Dials, the declination of the *Meridian*

or *Planes* Longitude, is accounted from the *Noon*

*Meridian*: And upon all *North* declining reclining

Dials, less than a *Polar* Dial, the *Planes* Longi-

tude is reckoned from the *Midnight Meridian*,

or twelve a Clock at Night; and in all *Polar* Di-

als it may be accounted from either *Noon*, or

*Midnight*, because the Longitude of the *Plane* is

always 90 deg. and in all *North* declining recli-

ning Dials, more than a *Polar*, it is found from the

*Midnight Meridian*, but the Complement to 180

deg. is the difference of Longitude, from the

*South*, see Page 12206 and 12207

You have in Figure 36, a Dial which sheweth

by the shade of the *Stile*, what People, whether

by Sea or Land, have the Sun just over their Heads

at such a time as you look upon the Dial; which



is performed by inverting that part of the *Territorial Globe*, which is included between the two *Tropicks*.

The Reason of this Inversion is, that the shadow the *Stile* being always cast towards to contrary part to the Sun, that is, if the Sun be *East*, his shade falls towards the *West*, &c. therefore is it necessary that the *Eastern* part of the World should lie *Westward*, and the *Northern* part *Southward*.

These Dials are best to be *Equinoctial* ones, on which this sort of Furniture is described, for it appears the best on these sort of Planes. The making of an *Equinoctial* is taught in Page 20, and this Furniture described after this manner; Your Dial being made, and a *Trigon*, as in Page 135, put into your *Trigon*, (besides the *Tropicks* and *Equinoctial*) 5, 10, 15, and 20 deg. of Declination, for that answereth on this Dial, for 5, 10, 15, and 20 deg. of Latitude from the *Equinoctial*, and transfer them (in obscure Lines) from your *Trigon* to your *Plane*; this being done, your *Perpendicular Stile* being made *Radius*, see the *Tangent* of 5, 10, 15, and 20, from the twelve a Clock Hour-Line, and draw obscure Lines thro' the Points parallel to the twelve a Clock, and they shall represent your Longitude; your Dial is ready for to describe your Furniture; then take a Map of the Place you desire to draw on your Dial, and turn the bottom upward, and describe the Country, according to its Latitude and Longitude, and your Work is done.



